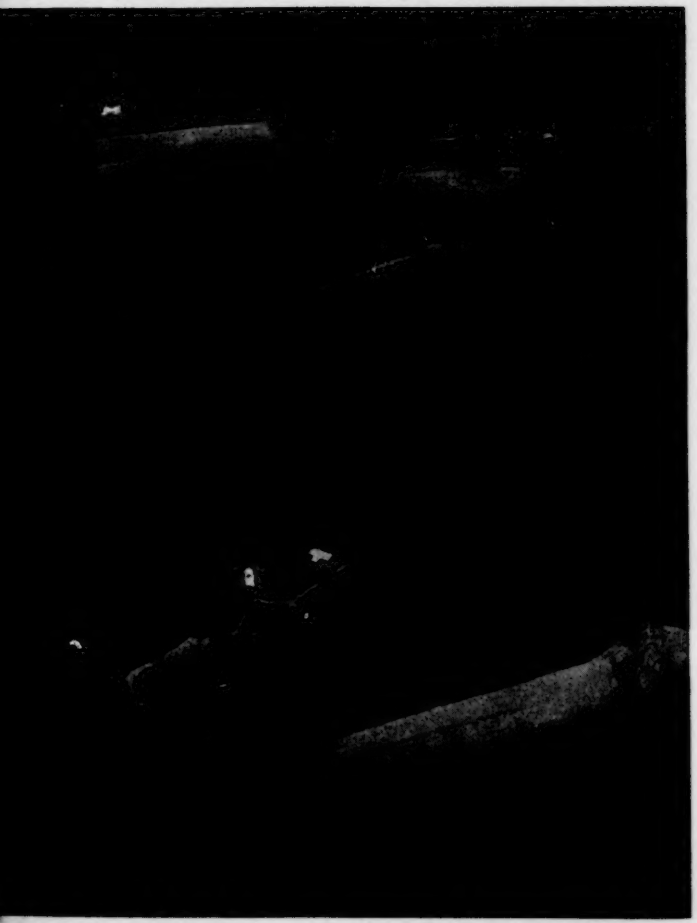

Volume 6, No. 3 **July 1951**

Physical Characteristics of Soils Related to Erosion

Soil Conservation Surveys Do the Job

Principles and Practices of Bench Terracing in Puerto Rico

The Need for Cover Crops in Corn Belt Agriculture

Reviews: A Water Policy for the American People; Forage, The Science of Grassland Farming; Water—Or Your Life

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OLD GLORY is a set of principles, a covenant of human rights, rippling in the breeze. So long as the great body of Americans respect the traditions and the principles for which Old Glory stands—so long shall the flag be a vision of hope, a shield against the storms.

VISIONS are elusive sometimes. But they have a way of coming down to earth. This thing called *soil conservation on the land* was once a vision—little more than the seed of an idea, the idea that farmers could work together to solve their mutual problems. The seed proved to be remarkably viable, for the soil conservation district idea has settled down like a protective blanket over our good earth.

There is more than physical resemblance between a contour-stripped field and the red and white stripes of Old Glory. The soil conservation district embodies the very essence of the rights and freedoms for which our flag stands. Cherishing those rights and freedoms, farmers have organized soil conservation districts that are of *local people,* by *local people,* for *local people.*

A soil conservation district is composed of local people who see their own problems and solve them, who see their own responsibilities and shoulder them. They are local people doing that which they should do, voluntarily, with no infringement of rights and liberties, with scarcely a law, rule, regulation, or tax. The soil conservation district, in action, is literally a bit of the freedom of enterprise that made America a land of opportunity and abundance.

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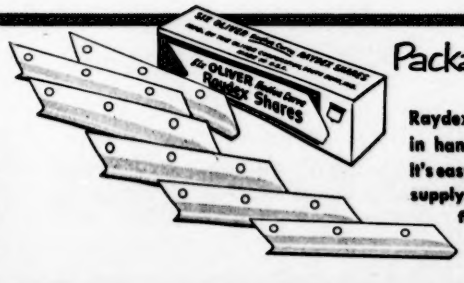

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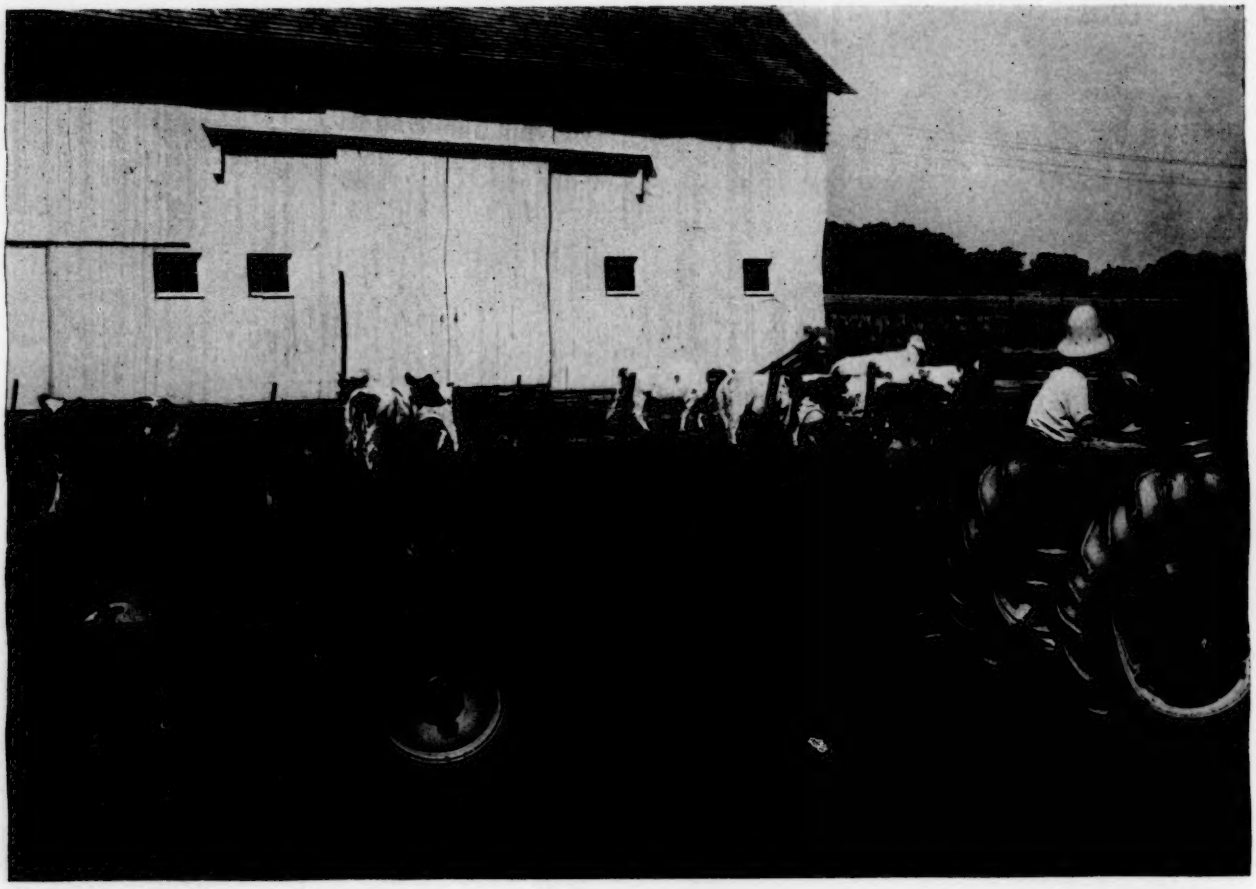

Good News for the Good Earth

ANY CONSERVATIONIST — both as a citizen and a specialist — can find good cause for satisfaction in the nation's latest livestock census.

This most recent tabulation shows our cattle population pushing the all-time peak. The count of swine and poultry reveals similar sizable increases. It bodes well indeed for America's nutritional future.

And certainly this swing to animal agriculture serves the best interests of our soil. Everywhere it is resulting in greater emphasis on pasture and hay crops — for feed, erosion control and for plowing under. Equally important, more and more valuable manurial residue is being returned to the land — both by grazing animals and by mechanical spreading. It is truly good news for the good earth.

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Journal of SOIL AND WATER CONSERVATION

VOLUME 6
NUMBER 3

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COVER. Conservation farming in all its aspects is growing in importance throughout the world. This Chester County, Pennsylvania, scene shows what a group of farmers did to improve and strengthen the land resources of their neighborhood. *Photo by Hermann Postlethwaite.*

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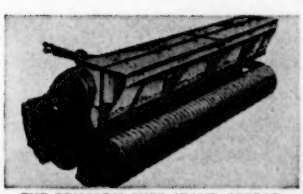

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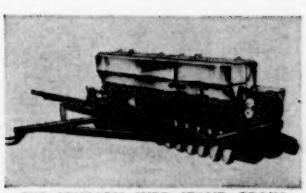

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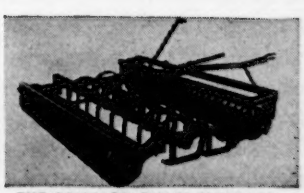

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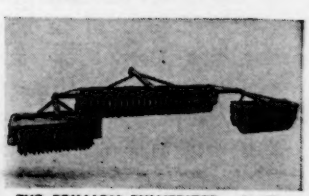

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From The Editor

H. Wayne Pritchard of Des Moines, Iowa, will take over the duties of Executive Secretary of the SCSA on January 1, 1952. We welcome Mr. Pritchard to his new post which presents a challenge and an opportunity to further build the science of soil and water conservation so important to the conservation movement. His capacity to do the job and give the Society the best in leadership are his greatest assets. Good luck, Wayne. We are all ready to help.

Morris Fonda, the Society's hard working President, is doing an excellent job in stimulating activity among the various Committees. Reports reaching my desk indicate that 1951 will be a banner year insofar as actual accomplishments are concerned. This also applies to the many active Chapters. It would appear that the SCSA is well on its way toward becoming a potent factor in advancing the science of soil and water conservation.

The Glossary Committee headed by Arnold J. Baur is completing its work for publication in the JOURNAL, beginning with the January, 1952 issue. Reprints will be pulled and bound into a single copy for sale to other interested persons. Incidentally, the Council at its spring meeting instructed its Executive Committee to investigate the possibility of publishing six issues of the JOURNAL beginning with Volume 7. We are wondering how many of our readers agree with this point of view?

We welcome three new advertisers in this issue of the JOURNAL — Wilson and Company, Chicago; Ruhm Phosphate and Chemical Company, Chicago, and the Brillion Iron Works, Brillion, Wisconsin. Members of the SCSA are urged to carefully review these advertisements along with others that appear regularly.

Advertisements appearing in the JOURNAL since the beginning of publication on July 1, 1946 have consistently been outstanding. The advertisers have related their well being to the land and used the space to show how their product is contributing to the conservation movement. In addition, many advertisers have also used their space to announce new conservation teaching aids such as films, posters, bulletins and other equally important devices. It is hoped that members, when writing to advertisers for these materials, will mention the JOURNAL. This is very important — not only to our members but also to our advertisers.

"Watershed Development in Soil and Water Conservation" is the theme of our Memphis meeting — November 12, 13 and 14. The Program Committee has done a fine job in setting up the agenda and scheduling outstanding speakers to cover the various subjects. Other local committees are working hard on tours, entertainment, and arrangements to facilitate the activities of the many standing committees of the Society.

Members of the Society — individually or as groups — should plan now to attend the Memphis meeting. Speaking collectively, we owe it to ourselves, to our Society, and to our profession to be in Memphis, November 12, 13 and 14.

The 1951 Report of the Annual Meeting of the Agricultural Commission of the American Bankers Association held in Des Moines, Iowa, is not only enlightening to the conservationist, but practical in its application. It contains the recommendations of eleven sub-committees — including soil conservation and forestry, and is being widely disseminated among banks throughout the Nation. Conservationists would do well to obtain a copy through their key banker or by writing direct to the Agricultural Commission, American Bankers Association, 12 East 36th Street, New York 16, New York.

Conservationists and others interested in foreign assignments under the Point Four Program are urged to read the item on page 155. Many of the assignments will cover land use, agronomy, forestry, agricultural engineering and other related fields. Readers desiring additional information should write to the Office of Personnel, United States Department of Agriculture, Washington, D. C.

"The Farm Equipment Dealer and his Soil Conservation District" is the title of a brand new publication just off the press. Copies may be obtained by writing to the Farm Equipment Institute, 608 South Dearborn Street, Chicago 5, Illinois.

The Need For Cover Crops in Corn Belt Agriculture

J. J. PIERRE

Cover crops reduce soil, plant nutrient, and water losses. They are needed in the Corn Belt because soil deterioration and erosion losses are very serious on many uncovered sloping fields throughout the area. The clean tilled acerage from the Corn Belt as a whole is proportionately too high in ratio to the acreage in meadow crops. Better rotations are needed. Cover crops will not replace good rotations but they can be considered as another cog in the wheel to help prevent the depletion of soil resources. More research, points out the author, is needed so that consistent and vigorous stands of cover crops can be obtained in a practical way with regularity.

THE TERM "COVER CROPS," as used in this paper, is defined as crops that are planted to cover and protect the soil when it is not protected by the regular crop. The ideal cover to protect the land against the elements which cause soil loss and soil deterioration is a heavy, living blanket of vegetation. Erosion, water runoff, and soil productivity are affected by many factors, but the type of cover is one of the most important single factors. Data on soil and water losses are consistent in showing that close-growing vegetation is effective in increasing water infiltration, slowing runoff, and protecting soil from erosion.

Cover crops (6) (7) influence soil, plant nutrient, and water losses in several ways. First, there is a reduction of total ground rainfall, in direct proportion to the density, height, and character of the vegetative growth, because the leaves and stems act as organs of interception and storage. A part of the moisture will remain on the plants as a film or as drops of water. Secondly, the intensity of ground rainfall is decreased. The larger drops are often shattered by vegetation into small drops which have lower impact effect on the soil. Splash erosion is practically eliminated because the raindrop energy is expended on the vegetation and is not allowed to strike the bare surface of the earth and explode the soil. Thirdly, the excess rainfall has less potential energy for moving soil. Each blade or leaf acts as a miniature dam to slow down water runoff. There is very little sealing of soil pores from minute soil particles in suspension, therefore, the rate of water infiltration is maintained and runoff decreases. Furthermore, freezing and thawing are less severe under cover; therefore, the soil stays free from frost and ready to absorb moisture later in the fall. There is also less danger of a light thaw, down to 1/2 inch or so, followed by a rain which might wash the entire sheet down the slope. Fourthly, if the cover crop consists of grasses and legumes they will not only add organic materials and nitrogen but they will help mobilize the various essential mineral elements for use by other plants and they will also condition the soil so that it is better able to resist the erosive forces of the raindrops even after plowing. A meadow crop usually improves the stability and size of the soil aggregates. Fifth, a cover crop will help absorb and conserve soluble plant nutrients which would otherwise be subject to loss by leaching. When water percolates through a soil containing nitrates and other soluble plant food the loss of nutrients is often high. Experiments (1) has shown that 17 times as much nitrogen may be lost by leaching from bare ground as from land planted to a cover crop.

Odland and Knoblauch (9) have reported that both legume cover crops and rye cover alone were helpful in the maintenance of soil nitrogen. After 40 years of continuous corn with no cover crop, the total soil nitrogen in the plow layer was 2,398 pounds per acre. Where legume and rye cover crops had been seeded in corn, early in August each year, the total soil nitrogen was 3,526 pounds for the legume cover and 2,664 pounds for the rye cover. Where crop rotations were followed on similar soil the average amount of nitrogen present was 4,000 pounds per acre. Average yields of consecutive corn for the last 34 years of the period, 1900-1933, were 48, 42, and 36 bushels per acre for a legume cover crop, rye, and no cover, respectively. Actually, the area planted to the legume cover crop could not be strictly compared to the other two because it received less nitrogen in the form of commercial fertilizer. These men found that cover crops increased the amount of water held in the soil by an average of three to four percent. Twenty-one

J. J. Pierre, Nursery Agronomist, Soil Conservation Service, with headquarters at Champaign, Illinois, works on vegetative problems and observational studies with forage crops in cooperation with the Soil Conservation Service and College Personnel in the states of Indiana, Illinois, and southern Missouri. He is a charter member of the Soil Conservation Society of America.

soil moisture determinations from April to August averaged 22.9 percent moisture where corn was grown without cover crops as compared to 26.6 percent moisture where rye had been used.

Cover Crops Are Needed In The Corn Belt

There is real need for cover crops in the Corn Belt. This area, including the states of Iowa, Illinois, Indiana, and parts of Nebraska, Ohio, Missouri, Minnesota, Michigan, Wisconsin, Kansas, South Dakota, and North Dakota produces almost three-fourths of all the corn grown in the United States. According to the December 1949 Crop Production report (3) by the Bureau of Agricultural Economics of the U. S. Department of Agriculture, 86,735,000 acres of corn were harvested for all purposes in 1949 in the United States. The Corn Belt states harvested 67.2 percent of this acreage or 58,304,000 acres in the same year—53,154,000 acres were harvested for grain, 2,381,000 acres were hogged down, and 2,769,000 acres were harvested for silage. In Wisconsin, 40 percent of the corn was harvested for silage, whereas in Iowa only 1.7 percent was cut for that purpose. The average for the 12 states was 4.7 percent harvested for silage. Most of the acerage for grain was harvested with mechanical pickers, however, in some states from ten to 25 percent was cut, hauled from the fields, and shredded.

The erosion hazard is much more severe where the stalks are removed either for silage or shredding than where they are left as a mulch on the surface. That, of course, has considerable effect on the need for cover crops. Duley and Russel (4) found that bare land on a five per cent slope lost nearly four times as much water, 1.95 versus .51 inches, and 19 times as much soil, 10.14 tons versus 0.54 tons, as land with a mulch of cornstalks. [1]Smith found in Missouri that corn stalks left on the soil in contrast to corn stalks removed, reduced erosion from late September to April by about one-half. The same principles apply in the case of popcorn, broomcorn, and sorghum. The Corn Belt states harvested 1,254,000 acres of sorghum for grain, 1,293,000 acres for forage, and 453,000 acres for silage in 1949. They also harvested 854,600 acres of miscellaneous clean tilled crops, such as popcorn, broomcorn, tobacco, sugar beets, and potatoes, and they grew 9,184,000 acres of soybeans. Ninety-four percent of the latter were harvested for beans while the remaining six percent were harvested for hay or plowed under. Here again, the kind of crop residue and the way it is used are important in preventing soil loss. Van Doren[2] found in Illinois that 4.7 times more soil is lost when the entire crop is removed than when the soybean residues are left on the surface. On a two-percent slope at Urbana the soil loss on contoured soybeans was 7,983 pounds per acre when the residues were removed as compared to 1,689 pounds when the residues were left on the surface. Therefore, even where the residues are not taken off and even where contour planting is practiced, erosion is still very serious on many sloping fields in the Corn Belt. Much of the land is still exposed to the splashing action of the raindrop and to the wear and tear from water moving over the surface. This lasts from the time of harvest in the fall until the following summer when a new crop has had an opportunity to make sufficient growth to protect the soil.

The total acreage of clean tilled crops in the Corn Belt is at least 17,342,000 acres. Illinois alone had approximately 12.6 million acres of corn and soybeans, slightly over six million acres of wheat, oats, barley, and rye, and about 2.3 million acres of hayland harvested for hay in 1949. Iowa, too, had approximately 12.6 million acres of corn and soybeans, along with 6.7 million acres of the small grains, and three million acres of harvested hayland. Wisconsin had about 2.6 million acres of corn and soybeans, 3.3 million acres of small grains, and 3.9 million acres harvested for hay. These figures do not include acreages of rotation or permanent pasture; however, they do indicate that *the present rotations are often too intensive on many Corn Belt farms,* and particularly on sloping land, if they are expected to do a good job of maintaining soil productivity. They also indicate that in the states of Illinois and Iowa, for example, approximately one-half of the acreage planted to corn and soybeans is followed with a repetition of a clean tilled crop the next season. A cover crop is needed and will do the most good in a clean tilled crop that is to be succeeded by another. Good crop rotations with sufficient meadow crops are the first need. Cover crops will not be needed as badly when rotations and cultural practices are adopted that will use each acre according to its capabilities and treat it according to its needs. However, in a rotation, such as corn, corn, grain, meadow, meadow, a cover crop between the two corn crops would be very desirable.

The Problem

The increased use of cover crops on clean tilled land still presents a challenge to agriculturists who are concerned with the future of Corn Belt Agriculture. More information is needed on plants that might be adapted and on the best methods of establishing different types of cover crops either at the time when the clean tilled crop is planted, at its last cultivation, or immediately

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Figure 1. Alfalfa cover crop seeded in corn July 5, 1949 and photographed May 14, 1950 on the Lester Pfister farm, El Paso, Illinois.

after harvest. In addition, the possibility of using volunteer plants and the feasibility of growing corn and soybeans on land where a cover crop has already been established need further investigation. In some cases, special machinery may also be needed. The failure of getting consistent and vigorous stands is probably the major reason why farmers have not planted more cover crops in the past.

The Corn Belt is not blessed with the long growing season found in southern states. Cover crops cannot be planted after the regular crops have been harvested with any assurace that they will make sufficient growth to cover the ground before winter. The plant breeders can relieve this situation by developing earlier maturing varieties of corn and soybeans. Earlier maturing varieties would be justified even if it became necessary to settle for slightly lower yields. Otherwise, it will be necessary to seed or maintain a cover crop while the regular crop occupies the land.

Progress In Solving The Problem

A number of trials have been conducted at several Agricultural Experiment Stations in order to test the feasibility of seeding different cover crops in corn and soybeans. Yellow blossom sweet clover, alfalfa, ryegrass, alta fescue, winter wheat, vetch and rye, other grains and soybeans are species that have been used with moderate success in the Corn Belt. [3]Shaller, Browning, and Wilson; and Wilson, Browning, and Peterson (10) report on seedings that have been made in Iowa over a period of 16 years. Seed was broadcast before and after the last cultivation of corn, and later in the summer it was planted in the standing corn with a one-horse drill. They conclude that (1) a rye and hairy vetch mixture has been the most successful cover crop tried in Iowa, (2) soil moisture is a very important factor in the successful establishment of cover crop seedings, (3) fair to good stands can be expected about one year out of two, (4) seeding in corn can be done anytime from July to late September but best results are obtained when it is done between August 15 and September 1, (5) soil loss was reduced from 4,200 pounds per acre with no cover crop to 400 pounds with a cover crop of rye and vetch at the Soil Conservation Experimental Farm in Page County, and (6) on plots receiving lime at Ames the use of a cover crop increased corn yields by 5.1 bushels per acre, per year. Similar results have been obtained at other stations.

Bauer, Lang, and Farnham (2) have seeded sweet clover at the last cultivation of corn on a continuous corn plot at Urbana for nine consecutive years from 1941 to 1949 inclusive. The stand obtained during that period was rated as follows: one failure, one poor, three fair, three very good, and one excellent. The average annual increase in corn yield above that of the check plots was 3.7 bushels per acre. In 1950, soybeans were

[3]Schaller, M. F.; Browning, G. M.; and Wilson, H. A.; "The Use of Cover Crops in Iowa." Unpublished data.

drilled between the corn rows at the last cultivation and they made an excellent cover.

Kurtz, Appleman, and Bray (8) have been studying the possibility of growing corn and soybeans in second year red clover, sweet clover, and other forage cover crops by turning under narrow strips 13 inches wide where the corn and soybean rows are to be planted, and leaving cover on the area of 26 inches between the clean tilled rows. They have applied various amounts of nitrogen and water and clipped the cover crops at regular intervals. They believe that the possibilities for this system of maintaining a cover are satisfactory and that good yields of corn and soybeans are indicated when proper management teachniques, such as the right timing on clipping and on applications of suitable amounts of nitrogen and water, are developed.

Mulch tillage is a practice that has been used in the preparation of a seedbed for corn and other crops. Most of the residue from the previous crop remains on the surface as a mulch to help control erosion and runoff. If the preceeding crop consists of grasses and legumes and if they are presistent and vigorous they can volunteer in the corn. Dreibelbis and Nair (5) have had yields of corn equal to yields obtained from conventional plowing, over a six-year period, plus good erosion control, by disking a two-year old meadow and leaving a good mulch on the surface. It may be possible to find special grasses and legumes with creeping rootstalks that may be even better than some of the species they have been working with. Crown vetch or Wagner pea might be very good legumes for this purpose.

A variation of the two systems just mentioned is the use of notched coulters and middlebuster sweeps which open a planting furrow leaving an undisturbed strip of cover about 20 inches wide between the rows. The middle strip is cultivated with the same sweeps at a later date. Here again, it may be necessary to have a combination of persistent volunteering plants and proper applications of water and plant nutrients.

When looking for the proper plant species some of our common weeds should probably be considered. Quack grass, for example, is a real soil conserving cover crop on many corn fields in the northern part of the Corn Belt. If we learn to live with it, quack grass may be even more beneficial as a soil conserving crop in the future than it has been in the past.

Another possibility that has not been explored thoroughly in the Corn Belt is the adjustment of the planting pattern on the clean tilled crop. A heavier rate of planting in the row with the rows spaced farther apart might be feasible. Every third row might be omitted. The cover crop could be seeded in May on the open third row. A slight reduction in the yield of the major crop would be justified.

Lester Pfister, farmer and hybrid seed corn producer, from El Paso, Illinois, has been very successful in establishing cover crops of alfalfa and grasses at the last cultivation of corn early in July. He uses a tractor-mounted broadcast seeder and covers the seed with a tractor-mounted spike tooth weeder. The main reasons for his success are heavy fertilization, good cultural practices, and irrigation. He irrigates during July and August to supplement rainfall, so that his crop receives about one inch of water per week. Besides increasing his corn yields in a dry season, irrigation and fertilization apparently insure good stands and a good growth of alfalfa plus grasses, such as bromegrass. Pfister uses a four-year rotation of corn three years (with a cover crop between each corn crop) and one year of the alfalfa-grass cover which stands over the entire season. The stand-over crop is clipped during the summer but all of the growth is left on the land. His cover crop is plowed in the spring, at a height of about ten inches, just before corn planting. His *level* prairie land is thereby exposed for a minimum period. Irrigation may be expensive for the average farmer; however, when land sells for $400 an acre it may be less expensive or more economical to irrigate than buy additional land. Pfister feels confident that his installations will pay for themselves, particularly in dry years, by increasing corn yields and at the same time providing for the successful establishment of his cover crop. Moreover, in a corn cash-grain economy the possibility of growing corn 75 percent of the time without damaging the land is a system that has considerable appeal.

Conclusions

Since most of us from the Corn Belt are proud to think of it as a bread basket of the country, it seems logical that we should do everything possible to keep it that way. Although cover crops are only another cog in the wheel in the maintenance of soil productivity, if it is possible to have them, they will support other soil building practices and help prevent further depletion of our soil resources. For the time being, we cannot expect to replace rotations with winter cover crops even in the cash-grain area in the heart of the Corn Belt. Rather, we can look upon cover crops as supplements to the rotation, for protection to the land when a regular crop does not furnish that protection.

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Soil Conservation Surveys to do the Job

JOSEPH H. WINSOR

This informative article is based on the fact that individuals, industrial concerns and governmental bodies are requesting help in solving their special land use and management problems. The author believes that soil conservation surveys should be tailored to meet these needs. This would be in addition to their use in farm planning for soil and water conservation.

THE SOIL CONSERVATION SURVEY is being put to use more and more by the American public. Surprisingly varied segments of our people are finding that this type of survey can provide them with essential information about their land. This information is a scientific tool which helps them to solve their land use and management problems, and is a basis for determining the practices necessary to complete the job. It is becoming evident to millions that no other type of land evaluation can provide these answers. Doubtless this survey is being used in many new ways which were not anticipated when first it was conceived.

The soil conservation survey, in addition to showing the significant soil characteristics, also designates the percent slope, the kind and extent of erosion, and the present land use. A number of other natural and cultural features are recorded, in addition, as the soil scientist walks over the land making the survey. Thus, with these other factors in addition to soil alone, this survey becomes a land inventory.

Space will permit only a brief listing of the fundamental characteristics of soils which, experience has shown, are very important in soil and water conservation planning. They are (1) effective depth (for root development and storage of moisture and plant nutrients which plants can use), (2) texture, (3) permeability, (4) type of underlying material, (5) natural soil drainage, (6) reaction, (7) organic matter content, (8) inherent fertility, (9) available moisture capacity, (10) thickness of surface soil and subsoil. Other characteristics may be important locally.

In nature, these characteristics are coupled and "weighted" in various ways. That is why we have so many recognizably different soils. For soil conservation surveys, soils are described, under a national coding system, according to ranges in these characteristics which are significant in soil and water conservation planning.

Soil Permeability is Important Factor

In recent years soil permeability has been the subject of much interest and investigation by the Soil Conservation Service. Permeability is commonly measured by the rate of movement of water through different recognizable horizons of the soil profile under specific hydraulic conditions. Permeability of various soil horizons is important in (1) establishing soil mapping units, (2) drainage and irrigation investigations, (3) assessing erodibility of various soils, (4) determining characteristics of water-disposal systems, and (5) determining suitability for certain types of plants. No doubt other important uses have been, or will be, found. Furthermore, the study of permeability and the soil characteristics which importantly affect permeability have given us a little better understanding of the character of and the complexities in soil behavior.

Soil conservation surveys are made at different scales and in varying intensities of categoric detail to fit regional needs. Areas of very intensive agricultural development, or of intricate, complex land patterns, may require maps at a large scale—eight inches to the mile or even larger. For large homogeneous land areas, maps of a small scale—two inches to the mile or even smaller, may be sufficient. Perhaps the "normal" or average scale would be four inches to the mile. In any event, the scale must be adequate to provide the detail necessary for farm conservation planning.

The co-acting factors of soil characteristics, slope, and erosion, as shown on the survey, are weighed and evaluated in their effect on agricultural use in the standard land capability classification. The resultant is expressed in terms of proper land use, treatment, and management to keep a specific unit of land permanently productive in the use to which it is suited (or capable). There are eight classes of land according to use capability, classified according to intensity of hazards to, and limitations in, use. Each class is represented on the map by a standard color, and when a soil conservation survey is "colored in" it becomes, in addition, a land use capability map. (The classification of land according to use capability is so well-known, and so much written material about it exists, that little detail is given here.)

Making soil conservation surveys for use in soil and water conservation planning of individual farms consti-

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Figure 1. Reconnaissance land capability surveys of Government land adjoining such reservoir areas help the Corps of Engineers, United States Army, determine land use and management.

tutes the main activity of soil scientists in the Soil Conservation Service. Yet there are many other uses to which our surveys may be adapted. In recent years the Soil Conservation Service has been receiving ever-increasing requests for surveys to provide land information for special purposes.

County War Board Reconnaissance Surveys

These surveys were made during World War II to provide the County War Boards with a semi-detailed land capability inventory of their counties. This information enabled these counties to gear their agricultural production to the war effort most efficiently, and still follow, broadly, good soil conservation practices. These surveys were also designed to provide the location and approximate areas of lands best suited to vital war-time crops such as peanuts, soybeans, and other food and fiber crops.

These surveys were made on aerial mosaic base maps at scale of two inches to the mile. The legends used were similar to those used on surveys for farm planning. In these war board surveys, however, similar soils were grouped, and erosion conditions were grouped for simplification. The categoric detail, naturally, was less than on the surveys made for farm planning. When the survey of the county was completed, copies of the colored map and accompanying report were distributed to the war board, and to other government agencies who were to use them.

Surveys of Physiographic Areas

In Kentucky, and no doubt in some other states, when a new soil conservation district becomes organized, the Soil Conservation Service prepares a rapid reconnaissance survey of the physiographic areas in that district. This survey and the accompanying descriptions designate the important blocks of land in the district according to significant differences in soil, topography, erosion conditions, and land capability. In our state, these significantly different areas in a district (county) run from about two to ten.

This type of survey and report were designed to provide the soil conservation district supervisors, the Soil Conservation Service personnel, and other interested persons and agencies with information about the general physical and agricultural characteristics of the land in the district. It is useful in acquainting new Soil Conservation Service personnel with the physical conditions county highway map at scale of one inch to two miles. When completed, it is transferred to a small "N" size district map at scale of one inch to four miles. It is reproduced at this scale, with a brief legend for use by the soil conservation district.

This district reconnaissance survey is made on the county highway map at scale of 1 inch to 2 miles. When completed, it is transferred to a small "N" size district map at scale of 1 inch to 4 miles. It is reproduced at this scale, with a brief legend for use by the soil conservation district.

Problem Area Map of State

The district reconnaissance surveys, in Kentucky, are used as a basis for preparing the soil conservation problem area map of the state. The areas shown on the district surveys are transcribed to our state map which is at scale of one inch to eight miles. In this conversion, due areas shown on the district maps must be omitted, and others may be generalized to some extent. The state map highlights the problem areas in soil and water conservation for the state as a whole, and is useful in certain types of broad-scale planning.

To carry this process a step farther, the various state maps are compiled into regional maps, and finally into the Soil Conservation Problem Area Map of the United States at a still higher level of generalization. The U. S. map is at scale of about one inch to 145 miles and is, of course, used to picture the problems in soil and water conservation of the country at large.

Survey of Railway Right-of-Way

The Chesapeake & Ohio Railway in 1947 asked the Soil Conservation Service to prepare a special survey to help them solve a problem that had been troubling them for some time. They wished us to recommend suitable plant materials and treatment to vegetate their right-of-way (with many cuts and fills) between Lexington and Mt. Sterling, Ky., a distance of about 31 miles. The purposes of the vegetation were (1) erosion control, (2) prevention of excessive ditch-silting, (3) crowding out weed growth, in part to prevent weed seeds from falling on farmer's fields along the right-of-way, and (4) beautification.

To provide information on which to base the recommendation, soil scientists of the Soil Conservation Service made the survey, from a C. & O. inspection car, in company with representatives of the railway. We used the C. & O. right-of-way blueprints for the base map. On cuts, the kind of soil, grade (1:1, 2:1, ½:1, etc.), and present cover (or lack of cover) were shown. The fills were of mixed, miscellaneous soil materials, hence only the grade and cover were shown.

According to these factors shown on the survey, recommendations for planting materials and treatment were made by the Soil Conservation Service. Choice of materials was limited to plants which would not easily burn in the dormant season, and which would (1) provide good cover the year around, (2) be "rugged," (3) be easy and cheap to establish and maintain, and (4) be attractive in appearance. The C. & O. has approved this project on a trial basis and establishment has begun. They expect to expand this project if the trial proves that it is practicable.

Survey for Kentucky Department of Conservation

The Division of Game and Fish, Kentucky Department of Conservation, is engaged in a stream-improvement program for fishing and other purposes. Their first priority is Elkhorn Creek, and its two main tributaries, North Fork and South Fork of Elkhorn, in the Bluegrass. These streams flow through Franklin, Scott, Woodford, and Fayette Counties. Elkhorn joins the Kentucky River in the northern part of Franklin County, north of Frankfort.

The problem is many-sided, and involves pollution, land use, siltation, dumping of refuse, biological problems, and engineering. The Director of the Division is conducting surveys to collect and interpret technical data in these fields in order to solve the over-all problem. He asked the Soil Conservation Service to provide the portion of the survey concerned with classifying, mapping, and interpreting of land conditions, to be used in solving the siltation problem and hence the attendant turbidity of the stream. This will also provide information on the fertility or mineral content of the adjoining soils, which has an important bearing on the aquatic population, including fish.

Conferences were held with the Kentucky Division of Game and Fish to determine their needs, and the survey was set up accordingly. The type of survey provided was a detailed reconnaissance soil conservation survey. The base map was a tracing-paper overlay on aerial mosaics at scale of 4 inches to 1 mile. Significant areas of soil, slope, and erosion were shown.

The amount of categoric detail was less than that used on the regular soil conservation surveys for farm planning. Factors of soil, slope, and erosion were grouped into somewhat broader mapping units for this

Figure 2. Showing heavy sod of Ky. 31 Fescue in a natural waterway. This is one of the ways of helping to prevent stream siltation.

Figure 3. Severely gullied areas such as this were indicated on surveys of Government land above reservoirs for the Corps of Engineers, United States Army. These require rapid treatment to alleviate silting.

survey. While giving the essential information needed, this procedure provided a more rapid, less expensive survey with larger cartographic units and hence easier interpretation. This survey covered only a limited distance from the stream channel, or about as far as the major drainage confines extend laterally. (Actual mapping usually extended somewhat beyond this, but the distant lateral upstream watersheds were not needed.)

Accompanying the survey was a report by the Soil Conservation Service. This included a resume of the geology by counties, the mapping legend, descriptions of the land-type units mapped, and an interpretive table. This interpretive table listed (1) each land type unit mapped, (2) past erosion on the unit, (3) erosion potential or silt-contributing rating of each unit, (4) land use, and (5) the indicated need or treatment for each unit mapped.

From this survey and report the Division of Game and Fish was able to study the over-all land problem, and to determine priority of treatment for the troublesome areas. The survey helped to relate and tie together some of the ecological factors into a neat package.

Land Surveys for Corps of Engineers

The Corps of Engineers, U. S. Army, encounters land management problems in developing and managing reservoir areas under its responsibility. The Corps has called on the Soil Conservation Service to assist it in determining the over-all land problems and to make recommendations for land use and management in such areas.

The Regional Office of the Soil Conservation Service, Southeastern Region, designated the author to consult with the Corps of Engineers and to make land surveys to enable the Corps to solve its broad land use problems in two such reservoir areas lying in Kentucky.

The Corps of Engineers, U. S. Army, Huntington, W. Va. District, requested a land survey and report on the Dewey Reservoir Project Area in Kentucky. The land area is approximately 17,450 acres in addition to the impounded area above Dewey Dam. The area is on John's Creek, a tributary of Levisa Fork of the Big Sandy River, and lies in Floyd and Pike Counties. The Corps desired this survey to determine the use of lands, according to their capability, within the government-purchase area. This information was needed to select areas for various types of recreational develapment, and for possible selection of agricultural areas for lease to farmers.

The Corps wished the survey to provide, broadly, the following information:

A—Areas suitable for cropland.
B—Areas suitable for upland pasture or hay.
C—Areas suitable for forest.
D—Spots of unusually severe erosion (areas of high silt-producing potential, hence of high priority of treatment).

It was decided to make a reconnaissance land capability survey.

Areas suitable for cropland were designated as I (green), and included Class I, II, and III bottoms, terraces, and colluvial or "toe-slope" areas. (No uplands were suitable for cultivation.) Areas suitable for pasture or hay were designated as VI (orange), and included dominantly Class VI uplands with small inclusions of Class IV and better areas of Class VII. Areas suitable for forest were designated as VII (brown), and included rough, stony Class VII upland. Small spots of unusually severe erosion were designated by simply locating an E on the area concerned.

The base map for this survey was an USGS topographic quadrangle sheet at scale of 1 inch to 1 mile. A report was written to cover the findings of the survey.

The Corps of Engineers, U. S. Army, Nashville, Tennessee District, requested a similar survey on the Wolf Creek Reservoir Area in Kentucky. This area lies above the Wolf Creek Dam in Russell County and extends through Russell, Clinton, Wayne, Pulaski, McCreary and Whitley Counties. Its greatest length by water is 102 miles. The government-purchase land area is about 33,000 acres. It is interesting to note in passing that Wolf Creek is the 7th largest reservoir in the world, on basis of acre-feet capacity.

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Physical Characteristics of Soils Related to Erosion

HENRY W. ANDERSON

Land management decisions involving the location of erosion sources and control of erosion can be made more soundly when they are based on determination and quantitative evaluation of the principal causes of erosion. The characteristics of soil itself is an important cause. Soil effects on erosion can be separated from other effects by making physical analyses on relatively few soil samples and by application of suitable analytical techniques.

LAKE MEAD IS SILTING UP, and so is Farmer Jones's pond. The Missouri is muddy for 2,000 miles, and there is a 10-ton boulder in what was once the Herbert's front yard. Clearwater Creek runs into the Blackfoot River; why is one sparkling clear, the other black with mud? English pastures are productive after centuries of use, but 76 per cent of the cropland of one southern United States county was retired from use in 35 years. What are the causes? Some people blame the soil, some the climate, and some the farmer. Technicians must provide quantitative evaluation and proof of the causes.

Erosion may be said to be the result of the action of the climate on the soil, with the results being modified by the topography and the vegetational cover. Differences in any of these bring about differences in the erosion hazard. One way of evaluating the separate effects of soil and cover differences on the erosion hazard for watersheds of similar topography is discussed and the use of the results illustrated in this paper. The results are based on a study of 14 watersheds of the Coast Range in southern California.

Physical Characteristics of the Soil as a Cause of Erosion

For a long time, careful observers have been able to say, "this soil is erosible and that soil is not highly erosible." In fact, it was just this qualitative segregation of soils into erosible and non-erosible which permitted one of the first attempts to relate erosion to the physical characteristics of soils. Twenty years ago, Middleton (6) proposed his now famous "Dispersion Ratio" and "Erosion Ratio." Middleton made laboratory measurements on some soil samples from widespread sources. He determined the silt plus clay in the soil in the absence of chemical or mechanical dispersion, called the Suspension Percent[1]; the silt plus clay after standard dispersion, called the Ultimate Silt plus Clay; and two other common physical characteristics of soil, the Colloid Percent by the water-vapor absorption method (7) and the Moisture Equivalent. Each of the physical measurements was expressed as a percentage of the dry weight of the soil fraction which was less than 2 mm in diameter. He defined the Dispersion Ratio and the Erosion Ratio as follows:

Dispersion Ratio = Suspension Percent ÷ Ultimate Silt plus Clay

Erosion Ratio = Dispersion Ratio ÷ Ratio of Colloid Percent to Moisture Equivalent

By comparing these ratios with the field reports of erosibility, Middleton noticed association between them which permitted separation of soils into erosible and nonerosible categories:

Erosible soils:	Dispersion Ratios greater than 10; Erosion Ratios greater than 15.
Non-erosible soils:	Dispersion Ratios less than 10; Erosion Ratios less than 15.

Soils characteristics which Middleton found related to such general expressions of the erosion hazard as erosible and non-erosible might well be related to quantitative expressions of erosion. If the relations are to have maximum usefulness, the quantitative expressions of erosion should be in terms related directly to erosion

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[1] "A sample of air-dry soil equivalent to 10 grams of oven-dry soil was placed in a tall cylinder of approximately 1,200 cubic centimeters capacity fitted with a rubber stopper. Sufficient distilled water was added to make the volume a liter. The cylinder was closed with the stopper and was shaken end over end 20 times. The suspension was allowed to settle until a 25 cubic centimeter sample which was pipetted at a depth of 30 centimeters consisted of particles of a maximum diameter of 0.05 millimeters." (6, p. 3)

damages. For this study, the expression chosen was sediment production from whole watersheds, which damages watershed channels, reservoirs, and water supply. The characteristics of the soils in a watershed play an important part in determining how much sediment is produced. The question is: How may the characteristics of the soils as they influence sediment production be determined and used? Four steps are involved: Sample the soil, measure the physical characteristics of the soil, relate the physical characteristics to measured erosion, and use the results to locate the areas needing control and evaluate how effective control will be.

Sampling the Soils of a Watershed

Sampling the soils of a watershed so as to determine the soil characteristics of the watershed is largely a problem of how to minimize the number of samples without undue loss of information. It is not feasible to sample all of the infinite variation in soils. Soil variations may be associated with every combination and level of each of the soil-forming factors: Parent material, topography, climate, organisms, and time (4). In soil sampling some sort of selection and averaging must obviously be resorted to. No information essential to our purpose will be lost by excluding variability which (a) would be averaged out for whole watersheds in any event, such as extremes of slope, local aspect, and local climate, or (b) may be evaluated as watershed characteristics for their direct effect on erosion instead of their effect on soils characteristics. Average density of vegetational cover is such a watershed characteristic. Thus, some standard conditions of certain soil-forming factors may be set up under which all soil samples are taken. Variability in the soil characteristics as determined by these samples represent soil differences. Deviations in soil-forming factors from the standard conditions may be expressed as watershed characteristics and evaluated as they affect erosion directly. This is one way that the number of soil samples needed can be reduced to feasible limits.

In application, the method employed will depend on the variability of soils and the dominant erosion processes in the study area. In this study of erosion, the soils on the watershed were youthful and profile development was limited; therefore, it was thought possible to restrict soil sampling to differences in the single soil-forming factor — parent material. Jenny (5) has called this a determination of a parent material *sequence* or *lithosequence,* obtained by arranging in order of magnitude the quantitative values of some physical characteristics of the soils. If these physical characteristics are found to be related to measured erosion, the lithosequence becomes an erosibility sequence, and within the errors of

Table 1. Average suspended sediment content of stream flow with associated cover density and mean soil characteristics of some south coastal watersheds, California.

Watershed	Area	Average suspended sediment[1]	Cover density[2]	Average soil characteristics[3]			
				Suspended si + cl[4]	Ultimate si + cl[5]	M.E.[6]	Colloid[7]
	Sq. mi.	ppm	Pct.	Pct.	Pct.	Pct.	Pct.
Cuyama	81	18,300	31.1	16.7	68.8	19.9	27.6
Cuyama	410	140,800	35.1	16.8	63.1	20.8	27.5
Cuyama	804	43,500	35.9	17.0	57.3	19.4	25.5
Cuyama	912	31,000	36.1	17.3	58.0	20.0	26.0
Sisquoc	442	11,100	48.7	19.1	62.0	25.0	30.1
Santa Maria	1,638	19,400	42.4	18.0	59.8	22.2	28.0
Santa Maria	1,763	30,200	42.3	17.9	58.3	21.6	27.4
Bradley	10	35,000	44.6	16.1	37.9	14.5	19.5
Ballinger	30	192,300	27.1	18.2	38.8	13.1	14.4
Tepusquet	13	7,600	44.8	15.1	68.1	25.6	36.2
Huasna	119	3,900	58.8	18.2	63.9	25.9	32.2
Alamo	89	5,300	53.9	19.6	63.0	23.9	30.3
Sespe	254	[8]2,370	[8]51.3	15.2	84.1	23.6	37.2
Sespe	254	[9]14,100	[9]19.0	15.2	84.1	23.6	37.2

[1]Except for Sespe samples, all are averages of depth integrated suspended sediment samples taken during period January to March 1941 by the U. S. Forest Service, Flood Control Survey Division. Sespe data from Santa Clara Water Conservation District reports 1931 to 1934.
[2]From cover type, fire history data of U. S. Forest Service, and cover density-age relationships developed by J. S. Horton. See Jour. Forestry Vol. 45, 1945, pp. 350, 351, and Table 1.
[3]Based on fraction of soil passing 2 mm seive.
[4]Middleton's suspension percent.
[5]Ultimate silt plus clay following standard Bureau of Soils method.
[6]Moisture Equivalent.
[7]Colloid by water-vapor absorption method (Robinson, 1922).
[8]Before 1932 fire.
[9]Average for first two years after 1932 fire which burned 76 per cent of watershed.

determination, the relative erosibility of the types of parent material may be given numerical values. When this has been done the erosion sources have been located and evaluated.

A geologic map (3) furnished a basis for locating and segregating the different parent materials in 14 watersheds. Soil samples of the 0- to 6-inch depth of soil were taken in each of the geologic types. The soil samples were all taken in a single standard condition similar except for geology — at average slope, 35 per cent, and under the average cover density for the cover type present. Since time was not available for replication of samples in all geologic types, the attempt was made to take the samples in the most typical areas, that is, where soil profiles were most representative and surface soil conditions were typical for that geologic type. Because of the subjective method of sampling that was used, the relative erosibilities obtained for the various geologic types must be considered preliminary. Eleven soil samples were taken, representing from one to five samples in each of the major soil-geologic types on the watersheds.

Measuring Physical Characteristics of the Soils

The soil samples were analyzed in the laboratory. The goal was to measure the physical characteristics which best expressed (1) the readily erosible fraction of the soil, (2) the rate at which more such fractions would be created when work such as running water or beating raindrops acted on the soil, and (3) the fractions of the soil which resisted creation of more readily erosible fractions. Numerous physical analyses were made on the soils, yielding Middleton's Suspension Percent, particle sizes from gravel to micro-clay, dispersed silt plus clay in the soil without shaking and upon shaking for periods varying from 2 minutes to 24 hours, the Colloid, and the Moisture Equivalent of the soils.

Before the relation between physical measurements of the soil and measured erosion from watersheds can be tested, however, the laboratory determinations of the soil's physical characteristics must be expressed as some average soil characteristic for the watershed from which the erosion measurements were made. For this, one of several choices might be made: (1) Simple average of a single soil characteristic or of ratios of several soil characteristics, (2) weighted averages of a soil characteristic or ratio, with the weighting based on the areal extents of the several soils, or (3) weighted averages of soil characteristics or ratios, with the weighting based on areal extents and other quantities and functions. As an adequate approximation the areal-weighted average, (2) above, was determined for testing and is given for the 14 watersheds in Table 1.

Relating Soil Characteristics to Erosion

Next, after getting averages of the physical characteristics of soils on whole watersheds, is the testing of how good these expressions are, which of them seem better, and determining their quantitative relation to the erosion produced from watersheds. A type of analysis which gives all three of these at once would seem just what the technicians ordered. Such a technique is available in multiple regression analysis (2). The results obtained are in the form of an equation which is compact in form and relatively easy to use. The parts of the equation can be lifted out at will and used to determine, quantitatively, how changes in one factor alone would be expected to affect erosion. This is precisely what is needed for comparing one soil with another as an erosion hazard, or evaluating how effective a control measure will be.

Quantitatively measured erosion should be used to obtain measures of relative soil erosibility. In the study here reported there were available measurements of erosion from 14 watersheds in terms of the average suspended sediment in the stream flow. The watershed areas ranged from 10.6 to 1,763 square miles and the average suspended sediment from 2,370 to 192,300 ppm. The physiography of the watersheds was similar; all were mountain watersheds of the west side of the Coast Range. The watershed cover was variable, ranging from 19 to 59 per cent. To avoid the possibility that cover differences might obscure soil effects and to obtain estimates of the effect of cover on sediment production, average cover density was included in the analyses. Precipitation during the period of sediment measurement had been fairly similar for all watersheds; statistical tests showed that the variations were not significant. The relation of suspended sediment to various physical characteristics of the soils and to cover density was obtained by regression analysis.

Results of this analysis are given by five equations in Table 2. Highly significant and useful relations between erosion and various physical characteristics of the soil were obtained. For example, Equation 1 indicates that suspended sediment from the watersheds varied as about the 3.4 power of the average Dispersion Ratio of the soils. The relation of the measured sediment production to that calculated from this equation is shown in Figure 1. Although no one of these equations is statistically better than another, some comparisons may be suggestive. The Dispersion Ratio appeared to be a somewhat better index of soil erosibility than the Erosion Ratio (compare Equations 1 and 2). Analyses indicate that the Suspension Percent might quite properly be divided by the Ultimate Silt plus Clay to form the Dis-

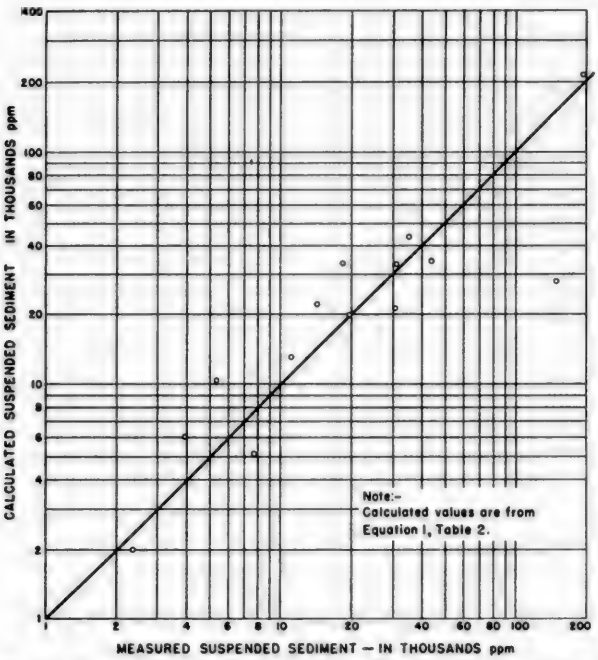
CALCULATED SUSPENDED SEDIMENT IN THOUSANDS ppm
MEASURED SUSPENDED SEDIMENT — IN THOUSANDS ppm
Note:-
Calculated values are from
Equation I, Table 2.

Figure 1. Relation of calculated erosion to measured erosion for some south coastal watersheds in California.

persion Ratio, since the individual effects have the opposite signs as indicated by Equation 3. On the other hand, dividing the Dispersion Ratio by the ratio of Colloid to Moisture Equivalent to form the Erosion Ratio would seem to be improper, judging from Equation 4, in which both regression coefficients have positive signs. The possibility that the Colloid is a better expression than the Ultimate Silt plus Clay of the binding fraction of the soil was indicated and deserves further tests (compare Equations 5 and 3). Other tests indicated that the per cent of Clay and the per cent of Fine Sand plus Silt were poorer expressions of physical characteristics related to erosion than were the expressions used by Middleton.

The physical measurements suggested by Middleton can be recommended as good indices of soil erosibility because of their simplicity and general usefulness.

The cover-density variable was found to have a highly significant influence on erosion in all analyses. The equations indicated that erosion varied inversely as about the square of the cover density in the range of cover encountered, 19 to 59 per cent density.

In this area of youthful soils, soil erosibility was dependent on the parent material—the goelogy—with the quantitative dependence being indicated by the physical characteristics of the surface soils in each geologic type. Application of the relation of erosion to the Dispersion Ratio, from Equation 1, Table 2, permitted arrangement of the soils developed from various parent materials in sequence as to their relative erosibility. These are given, together with various physical characteristics of the soil, in Table 3.

The results indicate that the most erosible soil was 75 times as erosible as the least erosible soil. It is recognized that this study must be considered preliminary in character and that more replications in some of the geologic types are needed to establish more definitely their relative erosibility and perhaps even their position in the lithosequence. Similar results were obtained relating soil characteristics and cover to deposition of sediment in reservoirs. These will not be discussed, since the purpose of this paper is to present a method and report a finding of the general usefulness of Middleton's physical indices of soil erosibility.

Use of the Results

The need for erosion control in an area depends upon two major factors: How much erosion is produced and how much damage the erosion does. Decisions of whether it is economic to control erosion cannot be met without adequate physical basis of where, how much, and how to control. How do the results of studies like the one reported here provide the needed physical basis?

The results of the study permit delineation of the

Table 2. Equations relating physical characteristics of soils and cover density to erosion.

Equation No.	Equation[1]	Correlation coefficient
1.	$\text{Log } E_s = 3.073 - 2.430 \log C + 3.427 \log DR$	.888
2.	$\text{Log } E_s = 4.786 - 2.486 \log C + 2.473 \log ER$	.878
3.	$\text{Log } E_s = 11.461 - 2.524 \log C + 2.189 \log S - 3.288 \log (si + cl)$	.849
4.	$\text{Log } E_s = 2.127 - 2,341 \log C + 3.861 \log DR + 1.353 \log \frac{Coll}{ME}$	.890
5.	$\text{Log } E_s = 10.279 - 1.788 \log C + 1.151 \log S - 3.164 \log Coll$	.854

[1] E_s = Average suspended sediment content of stream flow in ppm; C = average cover density on watershed, per cent; DR = Dispersion Ratio, ER = Erosion Ratio; S = Suspension; si + cl = Ultimate Silt plus Clay; Coll = Colloid, ME = Moisture Equivalent; and log = logarithms to base 10.

Table 3. Soil-geologic sequences of physical soil characteristics and erosibility for major soil-geologic types: Santa Maria and Santa Ynez Basins, California.

Geology[1]	Ultimate Silt Suspension	Ultimate Silt plus Clay	Colloid	Moisture equivalent	Dispersion Ratio	Erosion Ratio	Relative erosibility[2]
	Percent	Percent	Percent	Percent			
Miocene Continental (sandstones) Quaternary terrace deposits (limestone)							
Upper Cretaceous sediments (shale)	19.5	39.3	11.3	11.9	49.6	52.2	100
Middle Miocene marine sediments (shales and sandstone)	16.1	37.9	19.5	14.5	42.5	31.6	59
Upper Eocene marine sediments (shale)	22.4	61.3	27.5	26.5	36.6	35.2	35
Lower Cretaceous marine sediments (shale)	15.1	66.1	36.0	25.8	[3]23.2	16.8	7.4[3]
	15.2	94.1	39.0	23.4	16.1	9.6	2.12
	5.1	36.2	31.4	16.3	14.1	7.3	1.34

[1]From Geologic Map of California, Jenkins, 1938. Parenthetical expressions were from field observations at the particular places where soil samples were taken.

[2]From Equation 1, Table 1, with Miocene Continental geology taken as 100.

[3]The standard deviation of the Dispersion Ratios of this soil-geologic type, with five replications, was 2.1, that is about 9 percent of the mean, indicating little variation within the geologic type.

source areas of erosion, first from existing geologic maps, then by more intensive field examination of local variations in slope and cover. The indices of relative erosibility may be used to determine the average soil erosibility for a watershed, when the areal extent of the various soil-geologic types is known. The indices may be used together with equations relating erosion to watershed discharge, channel characteristics, and cover characteristics (1) in making quantitative estimates of erosion from watersheds. Thus, the average soil erosibility of a watershed is one more watershed characteristic which may be used in improving the estimate of expected erosion from a watershed.

How to control erosion and a measure of the effectiveness of control of erosion was indicated in this simple case by the effect of changes in cover density. Reducing the acreage of forest fires, for example, would increase the average cover density in the wild land areas. If cover density were thus increased from 31 to 47 per cent, erosion would be reduced to 44 per cent of the original rate. Other means of erosion control, involving treatment of agricultural land (stubble mulching, cover cropping, etc.) were found by use of comparative infiltration indices to be equal in effect to doubling the cover density; hence, these treatments could be expected to reduce the erosion from agricultural land to one-fourth of the original clean-tilled, untreated condition. Similar effects as to the result of rangeland treatment were estimated. Thus, economic evaluation and ultimately land management decisions in these areas could be made on a foundation of physically measured effects.

Conclusions

The evaluation of soil characteristics as they affect erosion may be made rather easily by making physical analyses of soil samples. The number of soil samples required may be reduced to relatively few if the technician takes advantage of his knowledge of the nature of soil variability and the erosion processes in his area, and fits this knowledge properly into his analytical technique. Tests showed that several physical characteristics of soils and cover density on watersheds were quantitatively related to erosion measured in terms of the suspended sediment in stream flow.

In an area of youthful soils, soil erosibility was dependent on the parent material — the geology — with the quantitative dependence being indicated by physical characteristics of the surface soils in each geologic type. The Dispersion Ratio of Middleton proved to be a simple and useful expression of erosibility as measured by the erosion produced from watersheds.

Physical determinations and quantitative evaluations of the principal causes of erosion give a sounder basis for land management decisions involving erosion control.

The author wishes to express his appreciation to Professor G. B. Bodman of the University of California for guidance in the physical analyses of the soils.

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Principles and Practices of Bench Terracing in Puerto Rico

JOSE VICENTE-CHANDLER AND R. M. SMITH

IN PUERTO RICO, where deep soils are classified by conservationists as suitable for growing cultivated crops on slopes up to 40 per cent, and where farmers plant slopes of 70 per cent or more to such clean-tilled crops as tobacco, bench terraces appear to have an important and definite place in a conservation program.

Unless major land use changes are adopted, there are believed to be approximately 300,000 acres out of the 2,100,000 in the Island which probably must be benched if a permanent agriculture is to be assured. Today, approximately 10,000 acres of cropland have been laid out for eventual bench formation and are being managed with that purpose in mind.

Early Bench Terracing in Puerto Rico

Probably the first man to build bench terraces in Puerto Rico was Mr. Walter C. Drier on his farm at Barrio Cepero in Rio Piedras, about the year 1910. The terraces that he built were relatively narrow, so that only three rows of sugar cane could be planted on each. As a supporting practice Mr. Drier used a trash mulch with great success. This consisted of merely allowing the cut tops to lie where they fell at harvest time, and of not cultivating the ratoon crops for several months. At the time, other farmers burned this residue every year, illuminating the summer skies at nightfall with a light visible for many miles. It is interesting that this practice of mulching with cane trash has just recently become accepted by farmers in general, after having lain dormant for almost four decades.

Mr. Drier states that in addition to the money saved in the cultivation and alignment of the trash between rows of cane, he obtained greater yields from the terraced fields treated in this fashion.

Most studies which have been conducted to determine the specifications, design and use of bench terraces suitable for Puerto Rican conditions were started by the Soil Conservation Service in 1937 in cooperation with the Insular and Federal Agricultural Experiment Stations, and the Puerto Rico Reconstruction Administration. Wide-spread testing of early concepts was also carried out on an Island-wide basis somewhat later. The various studies involved the construction of benches by hand and with plows. Most of the detailed testing was done at the Experiment Stations, the College of Agriculture, and on Puerto Rico Reconstruction Administration Projects in the La Plata Valley near Cayey. Some of these early benches are still kept up. Others are being destroyed through the apathy of the owners.

Slope and Mechanical Factors

The need for slope reduction on land as steep as that cultivated in Puerto Rico is rather obvious. Cultivating this land without reducing the slope causes large downhill movement of soil, simply in response to gravity. On loose Utuado soil, as much as 50 per cent of the measured erosion losses were accounted for by this gravity erosion during a two-year period of measurements. Even a person walking on such a field causes large soil losses, because the sandy material tends to roll freely whenever it is disturbed in any way. In addition to the seriousness of soil movement, per se, the stand of young plants is greatly reduced by the rolling soil. These purely mechanical factors demand slope reduction regardless of other considerations.

On clay soil the process is different. Small particles

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Credit is due to numerous employees of Soil Conservation Service Operations and Research; employees of the Insular Agricultural Experiment Station at Rio Piedras and of the Federal Station at Mayaguez; and others who have worked on bench terraces and have contributed to our present knowledge regarding them. Special credit and appreciation are due Mr. U. S. Allison, formerly (now in Washington office) Caribbean Director of Soil Conservation Service Operations, who for many years worked with bench terraces himself, and was a leader in the development and use of bench terraces by others in Puerto Rico.

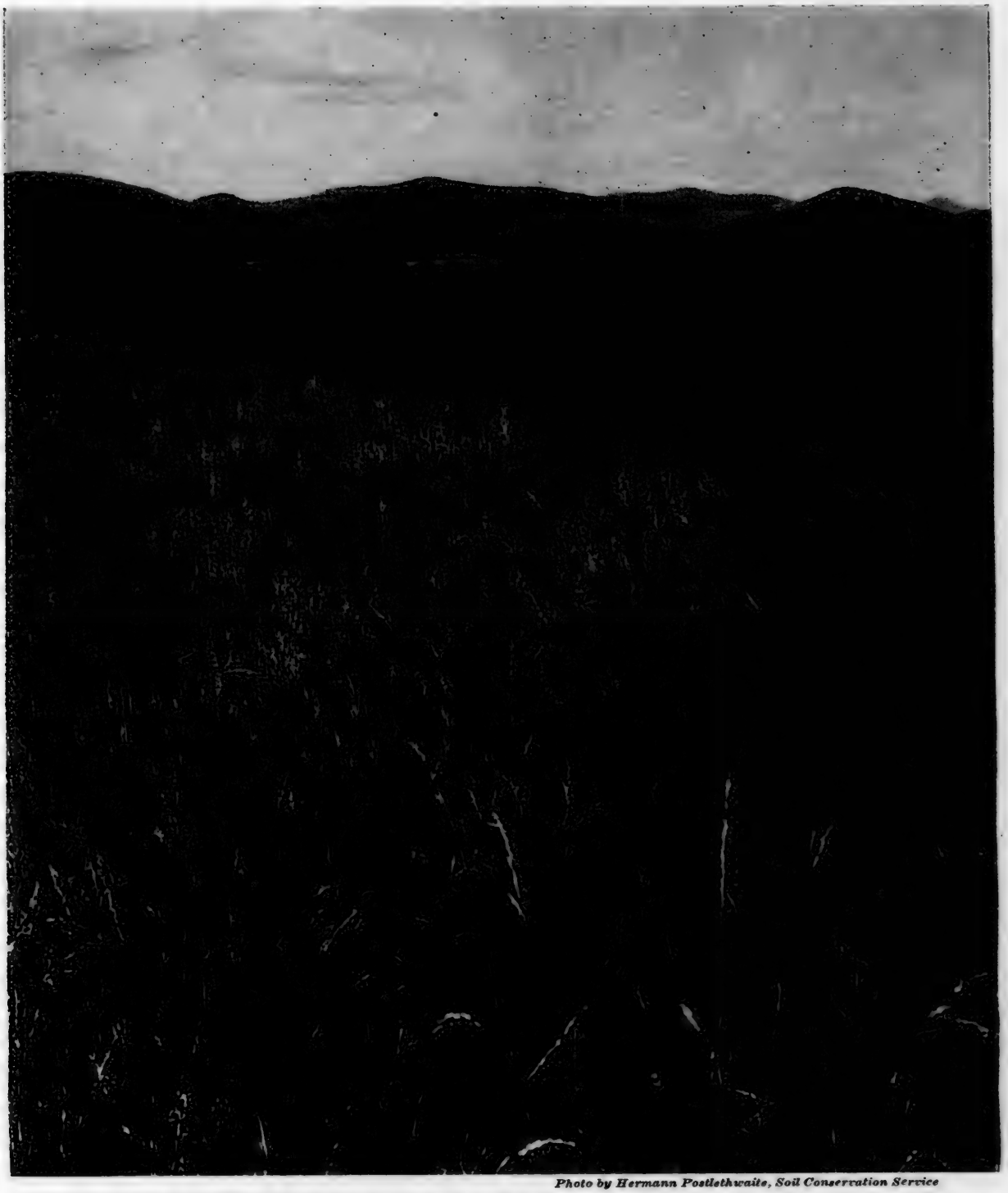


Photo by Hermann Postlethwaite, Soil Conservation Service

Suiter Fescue (Kentucky 31) *Festuca elatior arundinacea* is considered as one of the outstanding new grasses. It is a perennial cool season bunch grass, with a spreading habit of growth and heavy turf. The height of the grass will vary from three to five feet, depending upon soil fertility. It produces excellent forage and is used extensively in erosion control measures.

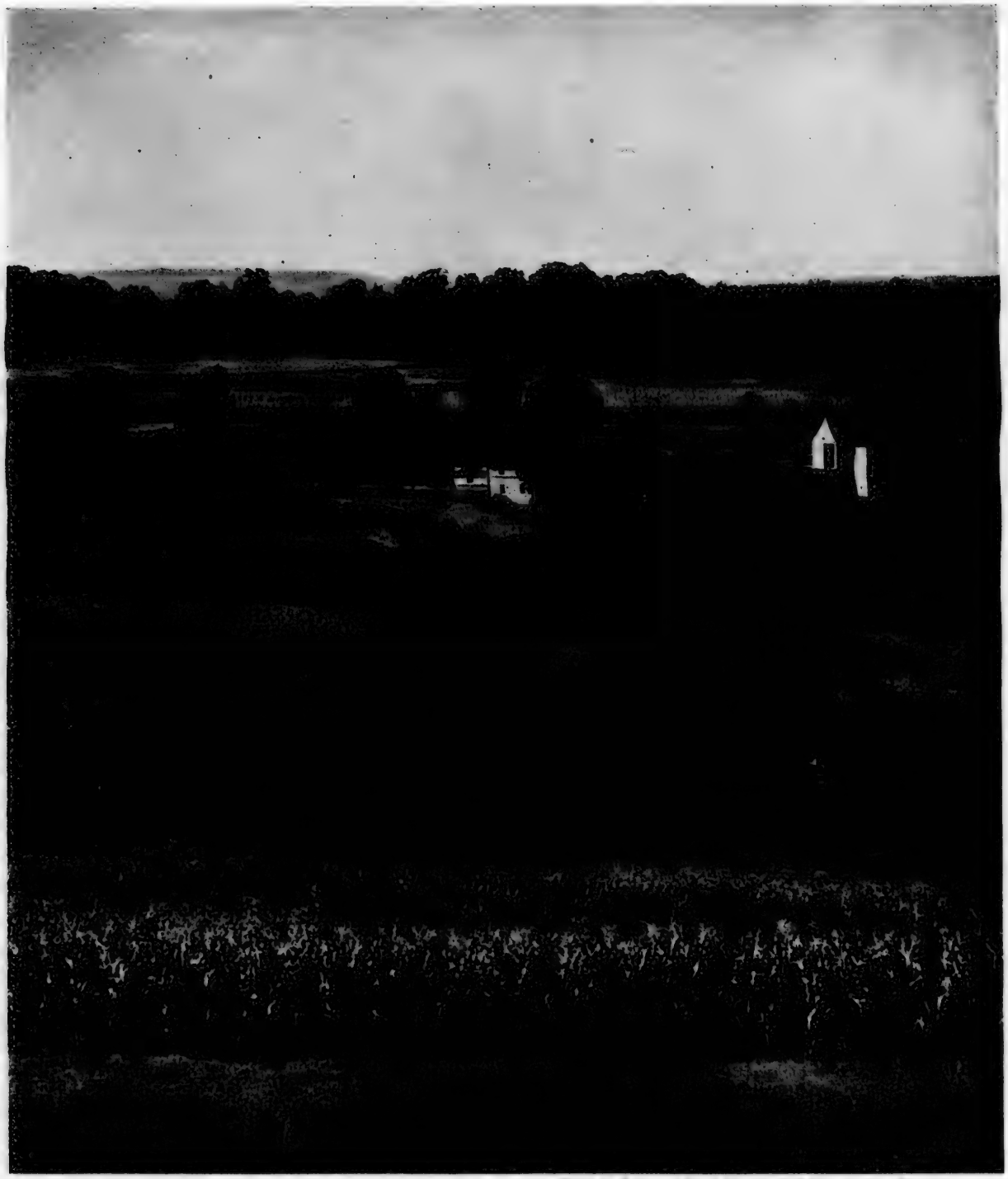
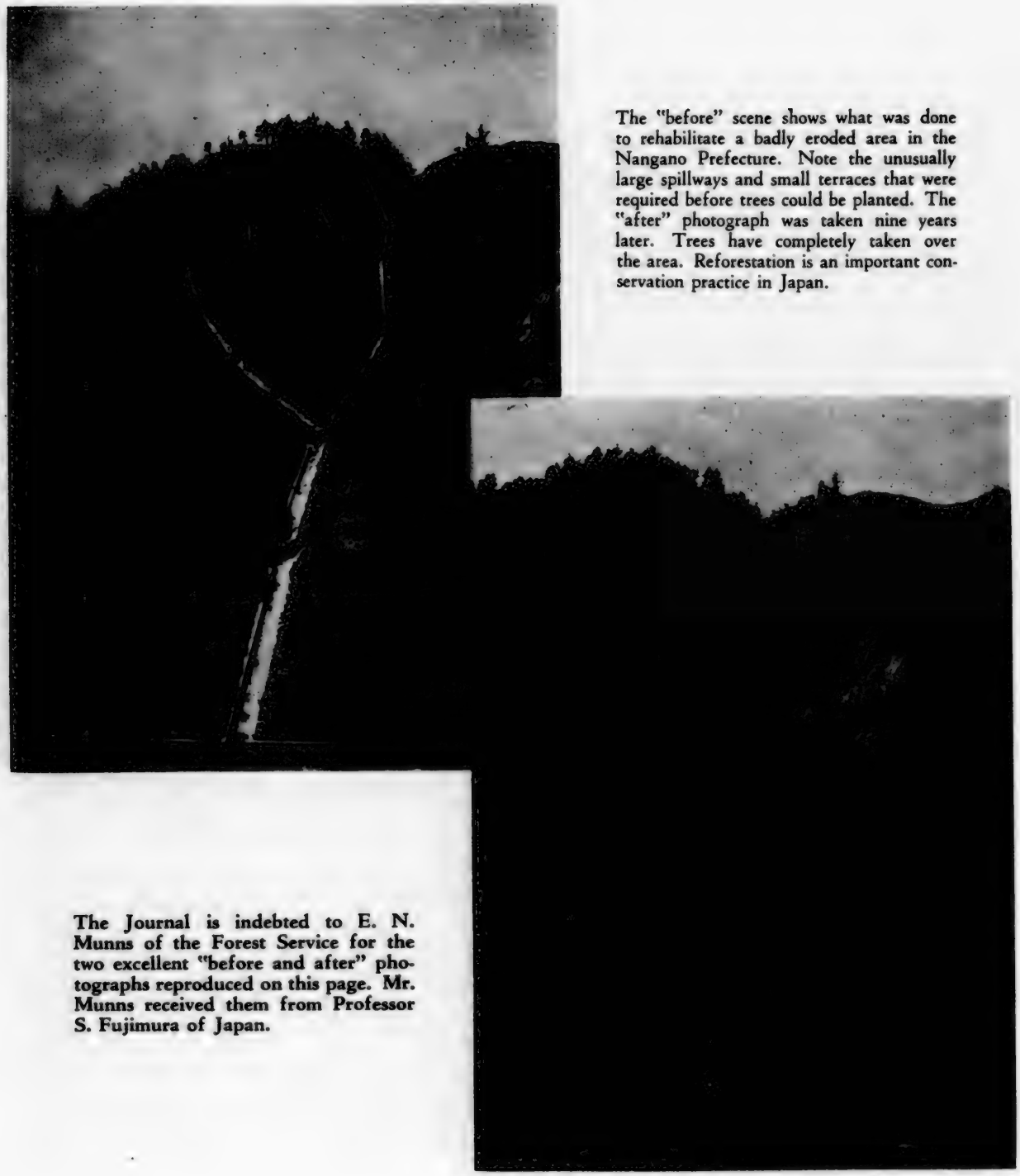


Photo by Hermann Postlethwaite, Soil Conservation Service

This fine example of conservation farming is on the Tocopson Creek Watershed—a headwater tributary of the Brandywine River in eastern Pennsylvania. An intensive neighborhood conservation program was started about a year ago to enlist the complete cooperation of the 75 farms that make up this small tributary watershed.

Photo by Gordon S. Smith, Soil Conservation Service

Wild waterfowl soon locate new water areas. Farm ponds can be made suitable for ducks by adding cover such as the multiflora rose hedge in foreground around pond. Pond shallows with lush aquatic vegetation are necessary to provide suitable breeding areas for ducks in ponds that are not too near buildings.



The "before" scene shows what was done to rehabilitate a badly eroded area in the Nangano Prefecture. Note the unusually large spillways and small terraces that were required before trees could be planted. The "after" photograph was taken nine years later. Trees have completely taken over the area. Reforestation is an important conservation practice in Japan.

The Journal is indebted to E. N. Munns of the Forest Service for the two excellent "before and after" photographs reproduced on this page. Mr. Munns received them from Professor S. Fujimura of Japan.

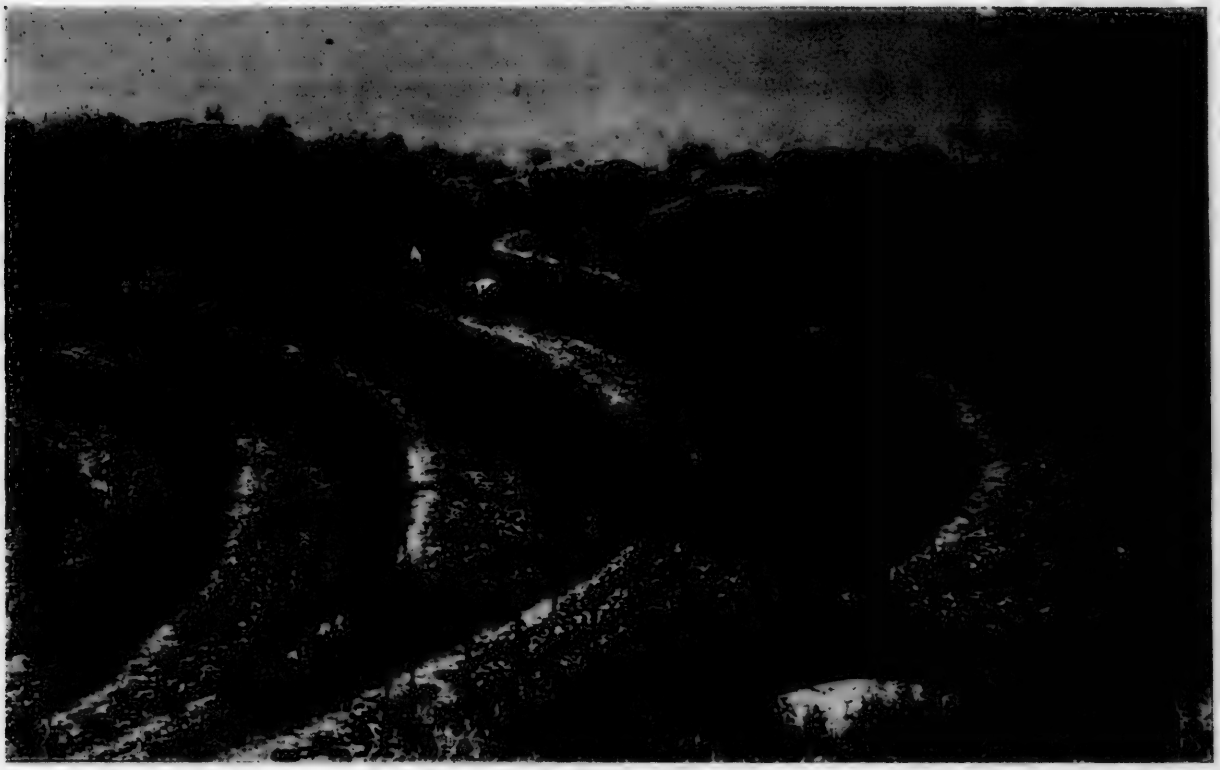


Figure 1. Successful crops of vegetables can be grown on narrow hand built benches with risers protected by grasses, on deep, red clay soil. However, the cost of such benches is high and the exposed clay is difficult to work and to cultivate. Soil organic matter must be re-built for continued cropping.

Excellent results have been obtained on wider, machine built benches with merker grass grown for cut forage, and fertilized with manure distributed in water from the dairy barn. Hand or machine constructed benches seem to be *mainly suitable for specialized uses.*

seldom move very far in response to gravity, but large clods sometimes break loose and roll far downhill. Moreover, the mere turning of the furrow slice in plowing causes a continual downward shifting of the top layer of the land. A definite idea of the magnitude of this effect is given in Table 1. Seven normal plowings produced a riser of 3.6 feet on slopes averaging less than 40 per cent. This shows why soil profile depth decreases with every crop if the soil is not held by benching. Also, virgin fertility and applied nutrients cannot be retained or increased to a highly productive and efficient level unless mechanical movement is controlled.

Measurements at Utuado show that the soil losses associated with such operations as cultivating and harvesting of sweet potatoes are very high. These operations alone caused 60 tons of soil loss per acre on 55 per cent slopes and accounted for the major part of the total loss from 20-foot wide plots over an entire year.

Mechanical Construction of Benches

Building bench terraces out-right, either by hand or with machines, has been tried extensively and has been found generally impractical. (Figure 1.) The cost at present is too high for most farmers to consider. This varies with a large number of factors, such as soil, slope, width of bench, and use of machinery. Actual figures which have been obtained range, generally, from $100 to $1000 per acre. Well-adapted machinery and experienced operators might reduce the costs considerably if benching was undertaken on a large scale.

With Utuado soil on the farm of Mr. Bartolome Rullan, hand-made bench terraces, ten vertical feet apart on 50 per cent slopes, with a flat bench width of ten feet, have been made for as low as $60 per acre by hand laborers earning $1 per day. This soil is easier to move than a clay. These are the cheapest hand-constructed benches on which definite records are available. The cheapness is influenced by the design, which provides for flattening about half of the horizontal distance and leaving the other half in the riser. The ten feet of horizontal distance in the riser between benches (i.e. 20 feet of total horizontal spacing minus ten feet of level

bench) reduces the amount of earth moving per acre of level bench, and it provides an average 1 to 1 (100 per cent slope) for the riser. Moreover, by maintaining a four foot cut into the weathered rock at a steep, 4 on 1,[1] slope, the soil moved by construction can be spread to form only a 6-foot vertical to 9-foot horizontal, or a 66 per cent slope of soil. This is not too steep to be used for cut forage, or for food crops like bananas. The horizontal bench and the riser shown in this photo are about double in width, and the cost was about eight times as great as for the 10-foot wide horizontal bench just described. This illustrates the fact that a narrow bench is much cheaper to build than a wide one. Gravity does much of the work in constructing a narrow bench. The cost depends upon the volume of soil and the distance which it must be moved per unit area of level bench created.

At the Baptist Mission Farm near Barranquitas, narrow benches with a vertical separation of only three feet have been built by hand on lateritic clay soil at a cost of about $100 per acre. The average bench is six feet wide. The original slope of the land was about 24 per cent. On this same farm, building bench terraces with a bulldozer is considered to be economically feasible for specialized purposes on slopes up to 20 per cent. A very experienced operator is required to handle the machine. The average cost per acre has been $60, using a 3-foot vertical interval between terraces, which forms a bench 12 feet wide. Federal (PMA) payments of about $25 per acre for this work further reduce the cost to the land-owner. However, these slopes are much gentler than where the major problems exist. Benching is not really necessary for normal cropping on 20 per cent slopes. These terraces are built for special crops to be grown under intensive management. The small vertical interval leaves a higher percentage of good topsoil near the surface than with deeper cuts and fills. This is a real advantage, but a greater vertical interval cannot be avoided on steeper slopes, in order to provide a bench of usable width.

Constructed benches on 50 per cent slopes of deep red clay soil are being put to excellent use by Mr. Rafael Vidal near Mayaguez. These benches, some of which are eight years old, give very high yields of merker grass for cut dairy forage, in response to treatment with manure carried onto the benches by water running from the dairy barn. Here, too, the benches serve a special purpose. They are considered to represent a sound investment, both for permanent conservation and for immediate production.

[1]All slopes are expressed as vertical drop per unit of horizontal distance.

Relations to Soil Profile Characteristics

On some Mucara or other shallow soils (lithosols) over hard volcanic rock, outright construction of benches is obviously not feasible. There simply isn't enough loose material above the rock to form a terrace. In addition, trials have shown that the water relations of the substrata are unfavorable. Excess water is held close to the surface by impervious rock layers or it comes out at lower levels to form seepy spots. The subsoil, too, is infertile in nitrogen and sulphur and in other organic matter factors, and is hard to work.

On deep upland clay soils (tropical latosols) the water-holding capacity and the permeability of the subsoil are relatively high, so no trouble in this respect has been encountered. However, in benching, the fertility is lowered to the extent that topsoil is deeply buried. There is also a great loss in ease of workability when the subsoil is exposed, and this is a very serious factor with cultivated crops. Moreover, the subsoil material puddles at the surface and severely limits water intake unless great care is taken to avoid trampling.

Utuado loam and sandy loam soils over rotten granitic (quartz diorite) rock are quite different from the clay soils mentioned. Workability of subsoil or rock is not a problem. The granitic material crumbles readily into sand to unlimited depth, and works easily even when freshly exposed. Erodibility of the subsoil material, containing little or no organic matter, is high. The sand

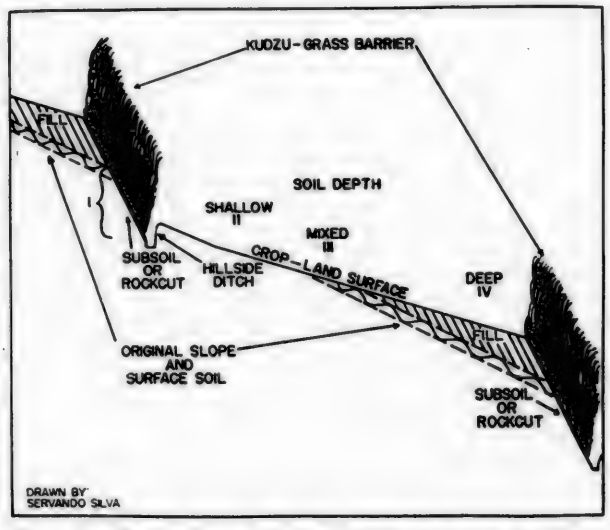


Figure 2. Sketch showing slope reduction by means of strong vegetative barriers. An original slope of 50 per cent has been reduced to 30 per cent by soil accumulation. There is a stable two to one drop within the four-foot wide barrier. Further slope reduction will be slow under good cropping practices. See Figure 3 for organic matter data at positions I, II, III, and IV.

rolls, creeps, or flows downhill freely in response to gravity or water until it is well tied down at the surface with vegetation. However, this is surface movement. The irregular sand grains (mostly feldspars) have a high angle of repose and the underlying rock is quite permeable. Risers have proved to be stable on slopes of at least two feet of vertical per one foot of horizontal distance. Cuts into the soft rock itself normally stand on slopes of about 4 on 1.

When surface soil is moved and buried on Utuado slopes the exposed material is low in fertility, particularly nitrogen, phosphorus, and sulphur. It also has less available water-holding capacity than the original profile (Figures 2 and 3). At the same time, the soil held above barriers is superior in water-holding capacity as well as in total organic matter reserve. So long as extreme care is taken to hold the soil within and above a barrier it is possible to have a net improvement in the average productive capacity of the soil. In the long run this might widen the choice of crops which can be grown successfully.

Water Control and Drainage

Most deep upland soils in Puerto Rico have adequate internal drainage. There are no data to show the effect of benching on this factor, but it is probable that with standard, sloping benches and spaced risers the soil profile drainage will be somewhat more thorough than in the original soil. The hillside ditches used as a supporting practice to control runoff also assure rapid drainage. Grassed waterways with natural vegetation are quite stable when left to carry away water from the hillside ditches.

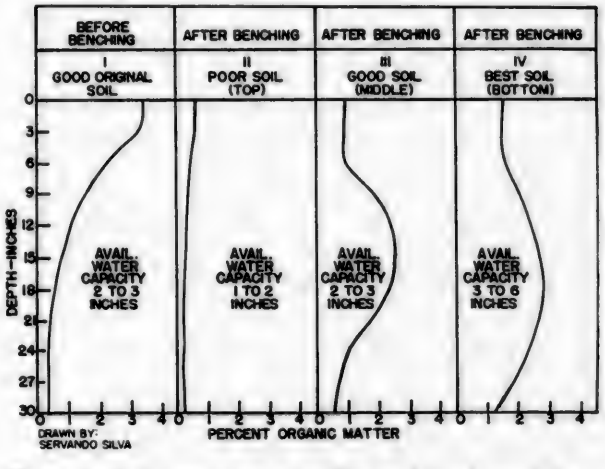


Figure 3. Soil organic matter profiles on Utuado sandy loam before and after rapid benching. The original slope was 50 per cent. After benching by plowing five times and cropping to tobacco the slope was 30 per cent.

Whenever moderately shallow soils overlying impervious substrata are benched, care must be taken to locate wet spots caused by seepage. Adequate ditch drainage must be provided for these locations. If care is not taken, large sections of the land may fall out near these spots and the benches will be damaged. Sometimes, after a heavy downpour has ended, a noise can be heard in steep fields and a large piece of land is seen to actually "fall out" and roll downhill, leaving a gaping hole.

Geologic Considerations

On slopes like much of Puerto Rico, normal geologic processes will always result in some mass movement of soil during periods of heavy storms. This action undoubtedly occurred during the formation of the virgin soils, and although sometimes spectacular, its total effect is small compared to accelerated movement caused by cropping.

As mentioned by Meyerhoff,[2] the Utuado area and other extremely steep lands of Puerto Rico are near a maximum slope governed by the stable angle of repose of the weathered material. However, the angle of repose of a material is greatly influenced by water. Assured artificial drainage, to limit or prevent pressure heads of water, may account for the relative stability of risers which are steeper than original slopes. The absence of impervious layers in deep soils is a strong contributing factor without which the necessary, excellent drainage would be difficult. Also, the greater stability of substrata compared to surface horizons, permits the use of steep cuts into rotten rock to provide a part of the riser for slope reduction, as at Utuado.

Accumulated experience with benches confirms early experimental indications that risers of two feet of vertical on one foot of horizontal distance are comparatively stable on deep red clay upland soils (latosols). More recent results, plus observations of old cuts and fills in Utuado sandy soil, give similar indications. Theoretically, rapid profile drainage provided by risers and graded ditches offers an explanation to account for the capacity for soil in these risers to stand at such steep angles. It is also probable that soil movement, even in risers which are called stable, is greater than geologic movement under virgin conditions. But with deep soils this regulated movement may not prohibit continued use of the land for cultivation. Erosion control equal to that under virgin conditions may be our goal, but it is seldom achieved.

Techniques of Slow Benching

Slow benching is the standard practice on private

[2]Meyerhoff, H. A.: Geology of Puerto Rico. University of Puerto Rico, 1933.

Figure 4. *Native grass* can be left on graded contours to start the formation of bench terraces. These grasses are not stiff stemmed and bulk soil movement will push through them as shown here when the soil is moved in quantity by repeated plowings to reduce the slope quickly. *Slower benching is better.* The best barriers have a width of about four feet and are a combination of grass with tropical kudzu. Hillside ditches may be used to support this type of benching, as shown.

The horizontal spacing of 24 feet on this 50 per cent slope gives a vertical interval of 12 feet, which is close to the maximum which is ever recommended. Details of benching under those conditions are shown in Figure 1.

farms in soil conservation districts: In fact, soil movement is held to as slow a rate as is feasible. This kind of benching is accomplished by stopping and holding soil which moves during normal farming operations. No expensive construction work is involved. The process is based on proper management. Plant barriers are chosen for effectiveness in holding soil and to suit the farmers' needs. In order to control excess water, as well as to provide rapid drainage, a hillside ditch is usually built below each barrier. (Figures 3 and 4.) The separation of the barriers across the slope is measured vertically, and varies, generally, from six to ten feet, depending on the slope of the land, depth of soil, drainage condition, and topographic features. Extreme conditions may permit greater vertical intervals, provided conservative tillage and well-selected crop sequences are used to prevent soil movement from ever building a riser of more than six or eight feet. Such heights can be held at slopes of 2 on 1 with good barriers of four foot width. The land for cultivation will thus be expected to remain between 20 per cent and 30 per cent, in order to avoid forming an excessively steep and unstable riser. At these slopes a balance may be established between soil loss and soil re-building. Effective legumes in the crop sequences are probably essential for this goal to be reached at a high and economical level of crop production.

Benches normally build up fastest at first while the slopes are steepest. The rate depends on the nature and number of the mechanical operations. In one year a three or four foot riser may be formed, consisting of about one half cut and half fill, and in two to four years the slope may be reduced by as much as 20 per cent, starting at 40 per cent or 50 per cent and changing to 20 per cent or 30 per cent. Under intensive cropping, with low vertical intervals, benches continue to form slowly until the slopes are between 10 per cent and 15 per cent. After that, uphill plowing can be practiced if desired, to prevent all further slope reduction.

Types of Barriers[3]

In general, barriers for erosion control may be classified as follows:

1. Stiff-stemmed grasses, such as merker and elephant grass (*Pennisetum purpureum*), Guatemala grass (*Tripsacum laxum*), etc.
2. Thin-stemmed grasses, such as native carpet (*Axonopus compressus*), molasses (*Melinus minutiflora*), etc.
3. Mixed coarse and fine-stemmed grasses.
4. Trash, which is eventually anchored by vegetation.
5. Rocks.

Tropical kudzu is believed to be of great value in reinforcing all of the five types of barriers, but it is not yet widely used.

1. *Stiff-stemmed Grass Barriers*

The main advantage of the strong stemmed grasses is that they hold the heavy clods which sometimes roll down hill when benches are plowed and built up rapidly. Grasses of this type were the basis for most of the early experimentation. They are an excellent source of cut feed for farm animals and produce heavily because rich soil and fertilizer are constantly being moved against them. Some farmers feed a cow with the produce from barriers on about three acres of crop land. The actual area in the barriers on three acres is normally about ⅓ acre. The extreme vigor and competition with cultivated crops is one of the objections farmers have to the use of tall grass barriers on a large scale.

2. *Thin-stemmed Grasses* (mostly native or volunteer)

Four-foot-wide strips of close growing native or volunteer vegetation are very effective in holding loose, fine

[3]Merker and elephant grass are *Pennisetum purpureum;* Guatemala grass is *Tripsacum laxum;* Carpet grass is *Anoxopus compressus;* Molasses grass is *Melinus minutiflora;* Tropical kudzu is *Pueraria phaseoloides.*

Table 1. Bench terrace formation by seven normal plowings against vegetative barriers on Catalina clay slopes of from 30 to 44 per cent. After the seven plowings the slopes were all 20 per cent or less and further benching would be slow.

Original Land Slope	Vegetative Barriers Results of Seven Plowings Against			
	Bench Width	Riser Formed		
		Cut	Fill	Total Riser
Per cent	Feet	Feet	Feet	Feet
38	11.0	1.5	1.5	3.0
41	10.7	1.9	1.9	3.8
44	10.0	1.3	2.1	3.4
36	9.5	1.9	2.2	4.1
30	12.0	1.5	2.1	3.6
Average 38	10.6	1.6	2.0	3.6

soil. In this respect they are far superior to merker grass, or other stiff-stemmed grasses alone, as there are no openings between clumps through which soil may be lost. In addition, they need not be planted, for if the barrier is laid off previous to breaking land which is in weeds or grass, the strip may be merely left unplowed, and, being on firm ground, provides immediate and effective protection. Molasses grass usually predominates in these barriers after a few years in areas where this grass is established.

Another advantage of this type of barrier is that the grasses spread to the steep cut below the barrier, giving quick and efficient protection. If all of the land is plowed, a much longer period is required before volunteer vegetation takes over on the steep cuts. Also, the low growing vegetation in native barriers causes less shade on the crops which are grown nearby.

Volunteer grass barriers have proved to be very effective on brown clay mountain land around Barranquitas, and on Utuado soil, where the sandy subsoil material readily flows or seems to melt down slope among the stems of coarse grasses.

3. *Mixed Species*

Probably one of the most effective types of barriers in certain respects is a combination of stiff-stemmed grasses with kudzu and fine stemmed grasses like molasses grass. Such combinations may provide the best features of all of the plants, individually, and in addition may serve as a permanent source of seed. The forage yield will normally be high, but management may be difficult because of the diversity of species. This type of mixture, also including Guinea grass, has been effective in experimental work at Utuado. Neither merker nor Guinea grass (Panicum maximum) gives such effective control when used alone on this soil.

4. *Trash Barriers*

Trash has been found moderately successful as a temporary barrier or in combination with stiff-stemmed grass barriers to prevent fine soil from filtering through. If trash alone is used, native vegetation must be allowed to come in rapidly to tie it down, for under tropical conditions the trash decomposes rapidly and becomes ineffective after one season.

5. *Rock Barriers*

Rock barriers have been used by institutions with an abundance of cheap labor, and where hard rocks are abundant on the land. There is also at least one Spanish farmer who uses rock barriers, which he builds, himself, by hand. He also carries topsoil from nearby river beds to build the bench. Such work is effective, but is considered impractical for almost all farms. Land is not scarce enough in Puerto Rico to justify such extreme measures except under special circumstances.

Soil Productivity on Slowly Formed Benches

It is usually quite noticeable that the upper crop row on each bench is poorer and requires more fertilizer than the others. This effect is, of course, caused by the loss of top soil from the upper to the lower parts of the bench. Normal organic matter profiles on rather rapidly-formed benches are shown in Figures 2 and 3. As a rule, the lower two-thirds of the bench maintains or improves its fertility while the upper third must be fortified with organic matter and fertilizer to hold up production. The use of legume residues or the application of manure is especially beneficial in this respect. The essential point is to slow the rate of soil movement enough, so that re-building of topsoil can approach the rate of removal. At Utuado it is calculated that this can be accomplished with soil building legumes and grasses if soil removal is kept below a rate of about eight tons per acre per year, and if only one cultivated crop is grown every two years. Then the land can be in soil building legumes and grass for about 16 to 18 months out of every 24.

Tropical Kudzu for Soil Improvement

The use of kudzu on bench terraces as a ground cover with which to grow such crops as tobacco, corn, and plantains with a minimum of plowing, offers great promise of slowing down soil movement, and at the same time of relieving the need for nitrogen fertilizer, while building up or maintaining the organic matter content of the soil. This system has many possible variations. It is still in the field trial stage, but the principles and theory appear to be sound.

Excellent results have been obtained with tobacco by planting it into a kudzu stand after the latter has been cut and the trash has started to decompose. It appears that this practice could be continued year after year with little plowing and very little cultivation. A cash or food crop every two years is the system with promise for extreme slopes. Plowing the trash into the soil, or temporary removal during establishment of the crop, has prevented slug or other insect damage. After kudzu is well established in properly spaced barriers it will not be necessary to reseed or to keep old plants alive in the crop land, because runners will move in from the barriers and cover the soil after cultivation ceases (Figure 5).

At Utuado, favorable tobacco yields have been obtained from mulched plots during three years. In 1950, significantly higher yields were obtained with kudzu trash than with clean cultivation, even though a complete fertilizer containing 100 pounds of nitrogen was used on clean plots compared to fertilizer without nitrogen on the kudzu plots.[4] The quality of tobacco following kudzu has been repeatedly judged equal to that with complete fertilizer alone.

A long rotation with grasses, as now followed on many farms, tends to slow down soil movement and to improve the structure of subsoil which is exposed on the upper part of a bench terrace. The systematic use of a productive legume-grass mixture would be superior to the volunteer grasses being used at present. The nitrogen and organic matter return to the soil would be several times as great.[5]

Other Aspects of Management

Erosion may be reduced in some areas by delayed fall plowing, to avoid leaving the soil bare during the period of heaviest rains. This has been done with tobacco at Utuado. Quick preparation of the land just before planting can save many tons of soil, because the heavy rains stop at about the required planting time. The use of hoes on very steep land instead of plows also slows down soil movement.

If benched land is used for pasture, precautions must be taken to prevent animals from tearing down benches and ruining the entire system. Some control may be obtained by tying the grazing animals, which is a common practice on most small farms. But possibly the best answer is to use the benched fields only for cut grasses and legumes, when not in cultivation, and never for grazing.

[4] 1500 pounds following kudzu compared to 1000 pounds by normal management.

[5] Smith, R. M. and Jose Vicente-Chandler, "Tropical Kudzu Moves into Puerto Rico." Crops and Soils. 3:12-14. (1951).

Figure 5. *Molasses grass and tropical kudzu* form the most nearly perfect soil cover and most effective stabilizer known for bench terrace risers when the combination is properly managed for seed and green manure. Here a crop of tomatoes has been grown and the bench immediately covered by runners from the kudzu and seedlings of grass. This combination should be the climax following native grass barriers, if correct management procedures are followed.

The tomatoes yielded more when grown with kudzu mulch than when well treated with complete fertilizer alone. Tobacco has also given increased yields with kudzu for green manure.

In order to permit laborers to move freely from one bench to the next, an unplowed strip may be left on the ridges, with narrow steps cut to provide footing. On some soils, steps are cut into the terrace risers, themselves, as the bench builds up. This is successful at Utuado.

The possibility that grass barriers might be a source of serious insect infestation has been considered. Some farmers have suggested this as an argument against native grass barriers, but widespread observations have failed to reveal any foundation for the idea. With short, native grasses, periodic or selective cutting with a machete gradually eliminates coarse, undesirable weeds, and no abnormal insect or disease damage has been noted on adjacent cultivated crops. These general observations are supported by detailed counts of tobacco stands on several parts of the Island. Moreover, grass is usually so prevalent around the normal, odd shaped fields that systematic use of spaced barriers would hardly be expected to alter normal insect populations or cycles.

Table 2. Soil Losses on different bank slopes on a Catalina Clay soil with original slop of 36 per cent, comparing native vegetation with an improved grass applied as sod.

Bank Slope	Cubic Feet of Soil Loss per 100 Feet							
Vertical	Fallow followed by Native Vegetation				Sour Paspalum Sod (Best grass studied)			
Horizontal	1937	1938	1939	1940	1937	1938	1939	1940
1 on 1	0	0	0	0	0	0	0	0
2 on 1	56	0	0	0	0	0	0	0
4 on 1[1]	10	0	16	7.0	36	5	1	1

[1]Significant losses were still occurring on this 4 on 1 slope in 1948 and 1949. The 2 on 1 slopes have continued stable.

Conclusions

There is little doubt that the use of bench terraces to control erosion and to increase production is a complex practice requiring careful study and planning on the part of technicians, and interest and care on the part of the farmers. To most farmers, bench terracing appears as a revolutionary idea. In order for them to use benches properly, they must accept a new set of values and a new approach to their land. It is necessary for them to learn a system of farming in which a number of essential points must be practiced conscientiously, or the terracing will fail.

Benching is an example of the complexity of conservation measures required when excessively steep land must be cropped to support many people. The land limitations in Puerto Rico, however, are not yet so serious as to prevent many farmers from seeking simpler solutions. In fact, if more land was looked upon as a heritage to be preserved or improved for the future, there might be less need for complex conservation practices like bench terraces. Careful, personal attention to simple practices on gently sloping land would greatly increase crop yields and the efficiency of crop production. This would encourage the use of steep slopes for forage crops or woodland, well within the capabilities of the land. But where recommended land use adjustments cannot be accomplished, o nslopes of less than 60 per cent, and on suitable soils, there is abundant evidence that bench terraces can be effective. Attention must be given to the *nature of the soil, topography and steepness, tillage methods, climate, water disposal and drainage, type of barrier and its management, soil treatment*, and *cropping practices.* Soil improving legumes in the barriers and in the cropping sequences appear to be a major link in the chain of success. The legume feature of bench terracing is now being tested extensively for the first time, with *tropical kudzu* as the outstanding general purpose legume in view.

Bench terracing has progressed slowly to its present position as a sound practice which performs its functions so long as basic facts and principles are not violated. There is no magic formula for success. Bench terracing, like most other complex farm practices, should be carried out well or not at all. It is the best remedy known for many difficult conditions, and unless new methods are discovered, benching is likely to continue as a major tool of conservation and production in Puerto Rico. Slow benching against grass barriers is present practice. Quick, mechanical benching may be used more in the future if pressure for level land becomes greater.

Soil Conservation Surveys

(Continued from page 128)

The details of designing and representing the Wolf Creek Reservoir survey differed in some respects from the Dewey Reservoir survey. The base maps were different, and only the cleared areas were considered. Areas then in woods would remain in woods, irrespective of their land capability. However, because of the basic similarity of the two surveys, it will not be necessary to describe the Wolf Creek Reservoir survey in detail separately.

Other Special Uses for Conservation Surveys

Soil conservation surveys have been used to help solve a variety of other special problems. They have been used as a basis for indicating and assisting in solving problems of water disposal, drainage, vegetation, pond construction, erosion control, siltation, and so on, for Army and Navy reservations, church organizations, cities, counties, industrial organizations, Boy Scout camps, and many others. Theer is a growing interest among tax commissioners in the use of farm land capability maps for land classification that will be useful for assessment purposes in rural areas. Thus the list of uses is growing steadily.

Conclusion

I am presenting some of my own conclusions with regard to designing and setting up soil conservation surveys for special purposes. In the first place, I believe that each survey should be designed to meet the special need, or that every need should require a survey appropriately tailored to fit it. An "all-purpose" survey is a delusion and a snare; it usually ends up by being a "no-purpose" survey.

To use a homely comparison, let us consider footwear. There is no "all-purpose" item of foot apparel. We use canvas sneakers for tennis, spikes for track, cleats of

(Continued on page 154)

Book Reviews

A WATER POLICY FOR THE AMERICAN PEOPLE, VOLUME I. PRESIDENT'S WATER RESOURCES POLICY COMMISSION. *U. S. Government Printing Office, Washington, D. C. 445 pp. Charts, Maps, Photographs, Appendix. 1950. $3.25.*

In venturing to comment on **A Water Policy for the American People,** we approach our assignment with humility and with many misgivings. We share the sense of gratitude which the American public should feel towards the group of able and devoted fellow-citizens who were assigned an almost impossible task and given a limited time to do it. We know the efforts they have made to elicit information and judgment from as many sources as possible. Let it be clear, then, that we are bent not upon fault-finding but upon using this impressive report as a basis of discussion.

The Commission, it will be remembered, was created by President Truman in January, 1950, to study the responsibilities of the Federal Government in relation to water resources. The American public was acutely water-conscious at the time. Local ground water decline had occurred in many places. New York City was resorting to bathless and shaveless days. The Hoover Commission, in its Task Force studies and reports to Congress, had publicized the forlorn way in which certain Federal agencies were dealing with our water resources.

The Commission's report emerges as three thick volumes. Volume II deals with **Ten Rivers in America's Future** and Volume III with **Water Resources Law.** Volume I, discussed here, outlines the Commission's views on water policy. A brief but uninspiring summary of it is available from the Superintendent of Documents for 15 cents. Since the purpose of the report would be greatly advanced by widespread public discussion, it seems unfortunate that the summary (a reprint of the introduction to Volume I) is not better written to stimulate immediate and intelligent interest.

The basic facts, of course, are simple: Water is essential to life, and the need for it increases rapidly with population pressure and technological advance. Our opportunity to use and conserve it lies between the time it falls and the time it reaches the ocean. The amount which falls is limited and easily wasted. The penalties of inefficient water management are severe and direct. We should like to see these truths set forth and reiterated until they are as clear to the average citizen as the fact that fire is hot and lead is heavy.

Equally uncompromising, but more difficult to express succinctly, are the facts of a second, more complex order. The functional relation between fallen water and the landscape expresses itself visibly in the watershed as a unit. This unit is an integration not merely of water and land-forms but of climatic conditions and living communities. Such communities include not only plants and lower animals, but man himself. They are dynamic systems, as truly as is the moving river, and it is equally dangerous to ignore the principles which govern their operation. The intelligent and effective relation of man to the watershed must begin at its upstream periphery, where it is possible to control the system before it gathers such momentum as to override his efforts. This, unfortunately, is the least spectacular approach.

The most complex problems arise from facts of a third order, lying in the realm of human choices and values. Obviously, what a society wants it will go after. If we have read the Commission's mind aright, it interprets our general goal as the development, by democratic process and the application of science, of an expanding economy. This it would do by a program of valley developments based on the fullest multiple use in order to justify the tremendous costs. It would recognize priorities of value and call for full and standard estimates of expected costs and returns. At the same time it admits that some exceedingly important values cannot properly be rendered in monetary terms. (One may guess what chance they would have on a standard accounting sheet.)

Our first concern, therefore, is to examine more fully what is implied by the idea of an expanding economy that the Commission uses as a basic assumption for its Report. We recognize that even to question the concept is to invite the figurative firing squad. Granted that the United States, with a small minority of the world's nations, still has a margin of safety in resources, is it wise to crowd this margin too far and too fast? Is the concept of a continually expanding economy actually tenable, or does it belong with the idea of perpetual motion?

Would it not vastly clarify matters if we set as a goal an economy that is in balance, just and efficient, and gives us the freedom and leisure to devote ourselves to the real ends of human living, which are qualitative, not quantitative? The nations that today best exemplify the values we cherish are those of northwestern Europe which have achieved just this kind of ordered economy. These countries have faced and respected the limitations of their environments. They have not driven hard to exhaust their utmost possibilities, but have left broad margins in reserve as supplements to the amenities of living.

After all, what is the rush? True there are severe,

even critical, local problems that must be met as quickly and wisely as circumstances permit. But, to use the words of the Commission itself, *"There is a sobering finality in the construction of a river basin development; and it behooves us to be sure we are right before we go ahead."*

This, it seems to us, raises vital questions having to do with appraisal, procedures, and technical means. As to the first, any opening up of new agricultural and industrial areas must be financed primarily by communities already organized. These communities represent a heavy investment of human effort and public and private capital. Taking present farm lands alone, it is abundantly clear that we have a huge task ahead to get them up to a proper level of productivity and permanent order. Does this not have definite priority over the opening up of new lands on a non-interest basis? We have been somewhat surprised that such organizations as the Grange and Farm Bureau have not expressed themselves vigorously on this question of public policy. Is it because each Western State has as many Senators as Indiana or New York? The record of Soil Conservation Districts to date shows that the cost, in public funds, is paltry compared to the tangible returns. Any weighing of prospective benefits, it seems to us, should take heavy account of the humdrum needs of areas already settled.

Next comes the question of procedures — the same democratic procedures which the Commission so ably endorses. Here again we may ask, "Why the rush?" It is precisely rush and high-pressure, as the Commission's second volume documents so convincingly, that are fatal to the democratic process. It is not enough to open hearings after a virtual *fait accompli* and consider that such hearings give the public its chance. The American people must have an opportunity to *grow* into wisdom for the final decisions concerning anything so vast as a river valley development. The public should not and must not be rushed by eager and plausible makers of plans, by impressive blue prints and accounting sheets. It should be wary of aggressive local chambers of commerce pumped up, all too often, by public employees, whose job is to perform our will, not create it. The people who must foot the bills and live with the consequences should have a fair chance to dwell with the problem and gage with some leisure and dignity the merits of its possible solutions.

This brings us to the final, fateful problem of means. The handling of a river valley is, in its essence, a problem in applied ecology — an integration of environment and organisms. The Commission clearly recognizes the importance of biology in many places. But one gets the impression here, as in most discussions of the problem, that the biologists are an outside group. Perhaps the biologists themselves are to blame. We suspect it. But nowhere are they really recognized as shapers of fundamental policy in any effective way. Instead they are cast in a minor, unhappy role as rear guards of the retreating Indian and bison, so to speak. The values they represent should have a hearing, true, but must not be allowed to interfere with the serious business of economics and engineering! Save the fish, save the scenery, if possible. If not — too bad. This may not be the bald view of the Commission, but it has been the invariable result in the past, even where "full review by all agencies concerned" has been the policy.

The truth is, and it should be plainly put, that there is no sound engineering or economics which does not treat biological hazards on the same high level as the more conventional hazards with which those disciplines deal. One of us has already set forth the character and importance of such hazards in engineering, and it may be interesting to note that a great many engineers took the trouble to express their agreement.[1] *The same strong case can be made in the field of economics.*[2]

It must be granted that far more data are needed to clinch the argument for skeptics, and the Commission has presented an impressive list of problems needing investigation. But even with our present, limited knowledge, a clear and rational order of approach to the problems of any river valley can be suggested. Such an approach would begin, not end, with setting aside on a generous scale ample wilderness and scenic preserves, and great forest areas. It would involve thoroughgoing protection of wisely allocated grazing and farm lands, using collaborative techniques already tested in organized Soil Conservation Districts.

This is a strategy of envelopment, moving in on the main problem from its margins, putting in order the upper reaches of the ultimate tributaries before proceeding downward and centrally into the mainstream for spectacular and grandiose structural work with its "sobering finality."

The guardian deities of a river are at its sources.

—Paul B. Sears *and* Robert D. Teeters,
New Haven, Connecticut

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[1]Sears, P. B. "The Importance of Ecology in the Training of Engineers." *Science* 106, 2740: 1-3, 1947.

[2]Mitchell, Wesley C. "Conservation, Liberty, and Economics." The Foundations of Conservation Education 1-12. Natl. Wildlife Federation. 1941.

THE WATER AND THE POWER. *By* A. N. WILLIAMS. *Duell, Sloan, and Pearse, New York. XIV+378 pp.,—maps, charts, photographs. 1951. $4.50.*

American Society is still faced with its greatest decision—it can continue to waste its substance in careless use of resources while it is trying half-heartedly to stem the tide of exhaustion by separatist, incomplete, and inconsonant attempts, or it can become a continent organism qualified to convert its resources to goods for human benefit and at the same time to conserve them for maximum, sustained productivity. Which of these roads America actually follows depends upon the intelligence and sobriety of the people, and this in turn depends upon the national psychology as developed by the educational and exhortative influences that are felt.

The Water and the Power is another effort to lead the public mind in hopeful directions. It is "*. . . a brief and succinct history of the development of the five* is concerned. The subject is dealt with first in connection with affairs on the Colorado, Rio Grande, Missouri, Columbia, and Central Valley of California, and then as a national issue involving America in its entirety.

A tremendous amount of hard-down digging must have gone into the portions dealing with the five drainage basins. Voluminous statistical and descriptive material, originally contained in numerous reports and plans, has been brought together and digested and passed on in remarkably interesting and easily read form. These summaries will serve the general reader as excellent nontechnical introductions, and will afford conservationists an improved idea of the complexities of the watershed problems. This information should be particularly valuable to professional conservationists in the West.

Mr. Williams does not believe that the traditional bureau approach will ever succeed to this ideal, nor does he believe that the valley authority approach (TVA style) will be adequate. He thinks there is "*. . . only one road to a truly national abundance,*"—a system of regional "*water/power*" planning and administrative units, each closely molded to fit its peculiar combination of circumstances and each coordinately directed from within, but all of the units should be linked together under a nationally centralized planning organization.

The author believes that, with some "elaboration and modification," the U. S. Bureau of Reclamation would be the logical organization to "*inherit the entire function of water development. . . .*"

—PAUL PHILLIPS, *Grand Junction, Colorado*

ECOLOGICAL STUDIES IN A MIDWESTERN RANGE; THE VEGETATION AND EFFECTS OF CATTLE ON ITS COMPOSITION AND DISTRIBUTION. *By* J. E. WEAVER *and* G. W. TOMANEK; *Neb. Cons. Bul. 31., Univ. of Neb., Lincoln; 32 pp., il. 1951.*

A pasture 1 mile long and ½ mile wide in the True prairie near Lincoln, Nebraska, provided an example of varying stages of range deterioration as the subject of this study. The vegetation is described by methods familiar to readers of the Weaver school of ecology, and forage production is reported on the basis of recurrent clippings.

Of interest to range conservationists is the analysis of the vegetation in relation to the response of the plants to grazing, as "decreasers," "increasers," and "invaders." Different segments of the pasture are classified as in "excellent," "good," and "fair" condition on the basis of composition, although the standards for delimiting the classes are not stated.

The varying condition of the pasture was attributed to uneven distribution of grazing by the 85 animal units using the pasture. To explain this, detailed observations were made on the movements and grazing habits of the cattle. This section of the report probably contributes more original information to grazing ecology than the vegetation studies, which were along lines already widely familiar to practicing conservationists.

—BEN OSBORN, *San Angelo, Texas*

WATER—OR YOUR LIFE. *By* ARTHUR H. CARHART. *J. B. Lippincott Company, New York and Philadelphia. 1951. 312 pp. $3.50.*

Water—or Your Life does an effective job of putting the nation's water problems in focus. It combines the best techniques of pulp fiction with an amazingly extensive web of facts. Of many recent books on "popular" conservation, it may be destined to be one of the most successful.

Carhart's searching factology is likely to awaken spectres of water conservation in many American homes. His correlation (of water—and your life) extends to the loaf of bread on the table and gasoline in the family car. So soundly does he develop his thesis, that professional conservationist and layman alike may conclude—"It's much later than we think."

Arthur H. Carhart, the book's author, is a prominent figure in the conservation and out-of-doors field. In World War I, he was an Army Medical Corps officer in charge of water sanitation. He was subsequently a member of the Forest Service and, later, a director of wildlife restoration funds for the Colorado Fish and Game Commission. He lectures widely and has often

been conservation's protagonist in public debates involving the country's natural resources.

As seen in **Water — or Your Life,** Carhart is at his best jabbing at apathetic attitudes. Water sore spots and enigmas in Texas City, Los Angeles, Atlantic City and New York do not seem remote when he drives home their potential far-reaching effects on pocketbooks, health and ways of life elsewhere in the land. Even when the book toys with highly explosive irrigation matters of the far West, the most hide-bound Main Streeter feels uneasily concerned.

From his numerous, unfavorable appraisals of them, it is obvious that the author is no exponent of "big projects" in formal conservation programs. His criticism of what he calls "super-engineering" works and proposals is, however, tempered with contrasting examples of their occasional necessity and value. The Yuma, Huntley and Minidoka projects are treated in the latter vein. The Central Arizona Project is "unjustifiable" according to Carhart's view.

In the main, **Water — or Your Life** is sympathetic with the "upstream engineering" philosophies of the Forest and Soil Conservation Services. With some reservations, it approves of agricultural and woodland practices which . . . "may directly contribute to more sustained flow of water in streams feeding from ground reservoirs. And by helping to prevent floods, they may reduce the usefulness of flood control dams."

With a familiarity he has demonstrated in a number of magazine articles, Carhart devotes several chapters to problem areas of the West. There, he is able to describe in stormy detail the No Man's Land that still exists between conservationists and opposing factions. At this point alone, **Water — or Your Life** will doubtless be damned or deified.

But whatever the point of view, most readers will agree that the new book performs several valuable services. It is a respectable critique of water conservation programs now existing; it offers standards for measuring others still in the proposal stage; and, with its careful index, it furnishes a ready reference to both ancient and modern history of water conservation in the United States.

—BERNARD A. ROTH, *Philadelphia, Penna.*

TERRA DE, HELMUT. *Climatological changes and soil Conservation in Mexico.* TURRIALBA 1 (1): *28-31. 1950.*

The author makes observations on both the recent and ancient freezings that have taken place on the snowy crests southwest of Mexico City. Comparing the existing glacial formations, he deduces that alternate phases of dryness and humidity have existed. This indicates the possibility of a change in the present climatological tendency by which serious water problems confronting that section might be solved.

Then he comments on reasons for exhaustion and erosion of the soil that seemingly could not be stopped. Men and recent governments applied themselves to the job without marked success. Water conservation is still an unsolved problem. Creation of a ministry of hydraulic resources was established to promote water conservation and irrigation to better meet the situation.

He emphasizes finally the fact that in Latin American countries, great sums are dedicated to construction of engineering works and other structures, but in fulfilling the program of the conservation of natural resources, the human factor has been overlooked. The people have not been educated for a sensible exploitation of the soil. Due to this fact, says the author, there will be little accomplished. He ends the article quoting William Vogt who said *"When our natural resources are in danger, it is imperative to think of moral erosion."*

—ALVARO RODRIGUES, *Colombia, South America*

POLITICA DE CONSERVACAO DE SOLO (*Soil Conservation Policy*). MARQUES, J. QUINTILIANO. *Department of Agriculture. Information Service, Rio de Janeiro Brazil. 1949.*

This work was presented at the first round table conference of soil conservation organized by the Rural Brazilian Society.

Brazil loses annually about 500 million tons of soil by erosion worth more than six million cruzeiros.

This loss is reflected directly in decreases in farm production.

The majority of farmers, nevertheless, show little interest in soil conservation. It is necessary to recognize that due to various social and economical factors they cannot allow themselves the luxury of preserving the fertility of the lands for future generations. They must meet their own needs.

There is a lack of balance between the collective interests and those of the farmers in order to give the farmer just compensation for any soil conservation methods that are not, for him, turned into an immediate profit.

On the other hand, existing wise conservation legislation is not fulfilled because of lack of proper execution.

In order to attack the problem properly, there is need of coordinated action on all fronts. It is of little use to organize technical research services and direct help to the farmer if he lacks financial assistance. Therefore the policy of soil conservation in Brazil should include three fundamental aspects: The technical, the economic and the social.

The lack of the knowledge by farmers is one of the principal causes for the poor use of the land. This shows the need of a broad program of education and persuasion

which should extend from the school child to the adult on his own land.

Reforms also are needed in present methods of rural credit, agricultural subsidy and taxation, and establishment of prices which would stabilize farm income.

Finally the author discusses the utility of zoning farm activities requiring the people now fighting against the low production of the soil to retire from the borderlands; checking some undesirable characteristics of rural real-estate; correcting undesirable farm practices, such as the inadequate distribution of farm products, burnings, parallel sowing on a slope; controlling lease and rural partnerships, and promoting the organization of cooperatives for the use and conservation of the soil.

FERNANDO SUAREZ DE CASTRO,
Colombia, South America

FORESTS AND MEN, *By* W. B. GREELEY. *Published by Doubleday and Company, Inc., Garden City, N. Y. 255 pages. Price $3.00.*

In these dark days of international crises, diplomatic tensions, domestic bickering and mounting taxes, we might wonder if the world is progressing backwards. A lot of us conservationists seem to harbor the same opinion about our progress in good land use. The corrective cure for such an ailment is two quiet nights at home with Colonel Greeley's new book, "Forests and Men." It's power packed with "good medicine."

"Doctor" of this amazing anecdote for "ailing" conservationists is a veteran of the forests, former chief of the U. S. Forest Service, leader of industrial forestry education—a man who intimately knows the big and little people of forestry and the forests. Brilliant, clear-cut writer, he has woven into a refreshing book the exciting drama of American forestry since 1900. So well has he done the job, that his book reads almost like fiction. And he has sprinkled it here and there with delightful touches of humor, personal incidents, and lots of names and places.

Nor has he sheathed the ax.

For it is inevitable in a history of this kind that the conflicts of personalties, ideologies and special interests clash time and again. Rather than side-stepping the issues, the Colonel dives in, reveals the facts, but with all the grace of a diplomat. Straight-forward—not ugly or vicious.

As a young forester, Colonel Greeley landed smack into an epic forest fire which destroyed three million acres of timber in the Bitterroots of Idaho. From then on the tempo never ceases as he unfolds the endless fight to protect the forests, the early ground swells of conservation, the great crusade of the Teddy Roosevelt-Gifford Pinchot team, development of public forests, state forestry and forestry at the grass roots.

Into his book, too, he weaves the story of free land and timber, "cut-out and move on," industrial progress and the expanding use of wood as a raw material. His last three chapters, "Teachers or Policemen in the Woods," "The Forest Balance Sheet" and "The Ways of Democracy" should be read by all.

The author may at first sadden you with his vivid accounts of the slaughter of America's virgin forests—the mining of timber to feed a young and wood-hungry nation. But skillfully, he traces the gradual turn of events towards better land use, brought about by the echoing voice of conservation forces, and by the simple logic of supply and demand. He points to the expansion of private forestry today as a tremendous campaign of tree growing and successive cropping backed by expenditures in the millions.

He winds up his book like this:

"For fifty years of scrambling over logs I have witnessed the battle between 'free land' and 'conservation.' Forces grouped under these opposing banners have fought and compromised, cooperated like practical Americans in doing first things first and then fought again. There have been the inevitable conflicts between earnest reformers who cannot wait and conservatives who hold to the status quo. And there has been the characteristic and fruitful reaction of the American people to so many contentions—a growing understanding and a getting to work at the grass roots. The greatest change in fifty years is the spread of forestry outward and downward. Forestry is now the common possession of us all. To me the fifty years have brought a rich experience in the democratic process at work, hammering out a national problem."

"Forests and Men" should prove an inspiration to all conservationists, as well as an enlightening enjoyment for the student and layman.

—S. L. FROST, *Washington, D. C.*

FORAGES: THE SCIENCE OF GRASSLAND AGRICULTURE *By* H. D. HUGHES, M. E. HEATH *and* D. S. METCALFE. *Iowa State College Press, Ames, Iowa, 1951, 724 pp., 234 illus. $6.75.*

Grassland agriculture covers a broad field of soil and water conservation. Included are proper land use, livestock feed as hay, pasture and silage, improved crop yields, land reclamation, and over-all farm economy. This book is as broad as the field. It is not a handbook of forages. It is a compilation of research results and the experience of 52 contributing authors presented in 60 chapters.

Text and reference books on forage crops are prone to be provincial as to geographic region and type of agriculture, limited as to species, and confined to the narrow field of production. The authors of this book

were drawn from the fields of crop production, soil management, crop breeding, soil conservation, economics, biochemistry, animal nutrition, bacteriology, range management, animal husbandry, dairy husbandry and agricultural engineering. Regional distribution of authors is good, with representation from the Northeastern Pasture States, North Central Corn Belt, Southeastern Cotton Belt, Northern Great Plains, Southern Great Plains, and Pacific Coast States. While many of the authors are located at Agricultural Experiment Stations there is a good representation of national authorities from the U. S. Department of Agriculture. Five of the authors, Bailey, Browning, Hafenrichter, Hawk and Heath, are members of the *Soil Conservation Society of America.*

Part I, Forages and Productive Agriculture, is devoted to an examination of the role of *"grass"* in modern farming and civilization with respect to land use, economics, soil conservation, soil fertility, and nutritive value.

Part II is concerned first with the botany of forage crops, seed production, crop breeding and legume inoculation, with the following 26 chapters devoted to a discussion of the different grasses and lagumes, and other forage plants. Many new plants which came into prominence because of the soil conservation movement are discussed.

Part III, Forage Production Practices, includes chapters on crop ecology, establishment, fertilization, and weed control. Some of the most important chapters deal also with hay and pasture seedings in each of the important climatic, edaphic and geographic regions of the United States. The regions include the Northeast, Central and Lake States, Humid South, Northern and Southern Great Plains, and Pacific Coast.

Part IV, Forage Utilization, covers the fields of hay quality, making and storage, grass silage and dehydration of forages. Pastures are discussed in different chapters on permanent, rotation, temporary, range and irrigated pastures. Separate chapters are devoted to the utilization of forages by dairy cattle, beef cattle, sheep, hogs and poultry.

A compilation of contributions of many authors could have led to confusion and lack of uniformity as to style. This apparently has been avoided by the three editors. H. D. Hughes, the senior editor-author, a past President of the Agronomy Society, is also the senior author of **"Crop Production"** (*Macmillan*), used generally in agricultural colleges throughout the country the past 20 years. His special interest, during over four decades at Iowa State Colleges, was always forage crops. M. E. Heath, of the Soil Conservation Service, is well known for his work in the Nursery Division, first in the Corn Belt and more recently in the Northeast States. D. S. Metcalfe has been primarily concerned at Iowa State College with methods of instruction, with special attention to forage crops.

Book reviewers often have a kind word for the Press. Frankly, this is one of the most attractive text and reference books on the market. The book contains many excellent illustrations, tied in closely with the text. Literature references are adequate and appear with the text. Each chapter is followed by a few stimulating questions. A number of tables of forage statistics are included.

In planning the book, the editors and authors had especially in mind its use by organized classes. As written, it will also be an excellent addition to the book shelves of soil conservationists, farm managers and research workers. Members of the *Society* will be pleased with the many citations to the use of grass as a tool in solving land and water problems.

—VIRGIL B. HAWK, *Ames, Iowa*

CONSERVATION OF NATURAL RESOURCES. *By* GUY-HAROLD SMITH, *Ed. John Wiley and Sons, N. Y. 1950. 552 pp. $6.00.*

AMERICAN RESOURCES; *their management and conservation. By* J. RUSSELL WHITAKER AND EDWARD A. ACKERMAN. *Harcourt, Brace, and Co., N. Y. 497 pp. $6.75.*

Our Natural Resources and Their Conservation by A. E. Parkins and J. R. Whitaker appeared in 1936; a second edition was published in 1939. It was rather extensively used as a textbook in the conservation field, and it is now succeeded by the two books listed above. The new book, **Conservation of Natural Resources,** edited by Smith at Ohio State University, follows closely the original Parkins and Whitaker in outline, and is published by the house that published the original. It repeats the original plan of a separate author for each chapter, some of whom are the authors of chapters of the 1936 book. Although the book suffers, as every collection of separate essays must, from lack of integrated treatment of the total subject, the material has been brought up to date and the format of the book is modern. Most of the numerous illustrations are new.

The second volume listed above is considered a successor to Parkins and Whitaker largely because the two have an author in common. The authors of the new book, **American Resources,** now at the George Peabody College for Teachers and the University of Chicago respectively, have written a completely new book. Although the general subjects covered are much the same as in Parkins and Whitaker, there has been careful selection and consolidation of the material included. There is a good discussion of general conservation problems in the introduction and conclusion.

E. H. GRAHM, *Falls Church, Va.*

Recent Research Reviews

JAMES H. STALLINGS

The Reviews by J. H. Stallings that follow are a regular feature in the JOURNAL. It is hoped that the projects reviewed from time to time will be helpful to conservationists everywhere. Members of the Society are urged to indicate their interest in the kind of research work that should be reviewed.

Range Cover Tames the Raindrop. *By* BEN OSBORN; *USDA-SCS, Fort Worth, Texas, Multilithed. November 1950.*

The explosive energy of the falling raindrop is the prime mover of soil and plant nutrients from range lands. Each drop strikes the earth like a tiny bomb, blasting soil particles into the air or churning soluble plant foods into the surface water. Runoff then serves as a ready carrier to transport this priceless cargo beyond the reach of forage-producing plants. Beating against bare soils, raindrops close the door to their own entry. Accumulating on the surface, they provide the runoff water to carry away the detached soil materials. They concentrate in streams to create floods and drop their loads of sediment in vital storage reservoirs, leaving the range soils dry in the root zone.

The raindrops break down the loose crumbs of the surface soil. The detached particles mix with the surface water to form mud, which seeps into the crevices and pores of the soil, plugs the worm holes and root channels, and seals them. As rainfall continues, it churns more and more topsoil into puddles of mud which finally overflow to lower levels. Thus the ground can be waterproofed in a few minutes. The mud left behind after the rain congeals into a tight crust which inhibits plant and animal life.

Nature's answer to this hazard is to cushion the fall of the rain with a mat of grass. The pliable blades yield to the falling drops and rebound like the net beneath a descending trapeze actor.

On the average 750 pounds per acre of cover reduced splash 50 per cent, 1250 pounds was 75 per cent effective, 2000 pounds 90 per cent effective, 3000 pounds 95 per cent, and 5000 pounds or more reduced splash 98 to 100 per cent.

Methods of Determining Ground-Water Levels and Movements. *By* WILLIAM W. DONNAN *and* GEORGE B. BRADSHAW; *USDA-SCS, Multilithed. January 1950.*

This discussion deals primarily with the use of piezometers in determining ground-water levels and movements. It was concluded that stream lines of flow can be charted about drains, tile lines, sumps, wells, canals, springs or any spot where information is needed on ground-water movement. If the source of the excess water can be determined and the direction it is moving a drainage system can be designed to intercept that flow or check it at the source. Likewise, investigations of drainage devices already installed will indicate whether they are functioning properly and give clues to betterment of existing and future design.

Color Tests for Clay. *By* D. L. GOODMAN; *The Reclamation Era, Vol. 36, No. 11, pp. 219-229. November 1950.*

The author describes a method which enables one to find out how much and what kind of clay is present in soils and rocks by a "color test." The way the clay changes color when certain dye solutions are added gives away its name and weight. A minimum of time and laboratory facilities are required to analyze clay by this method. It enables rapid evaluation of the engineering properties of rocks and earth materials and the quality of agricultural soils in irrigated areas and can be readily evaluated for the kinds and amounts of clays present.

Granule Size *vs* Crop Response. *By* VINCENT SAUCHELLI; *Amer. Fertilizer and Allied Chemicals, Vol. 113, No. 7, pp. 11-12 and 26. September 30, 1950.*

Large scale investigations were conducted in Sweden during 1939-1943 to determine the advantages of granulated over powdered superphosphate. It was discovered that granulated superphosphate increased to an unprecedented degree the utilization of the phosphoric acid in the fertilizer and produced favorable conditions for a better utilization by the plant of phosphorus and other nutrients in the soil.

When powdered superphosphate is broadcast, the plants utilize merely a negligible portion of the phosphoric acid, whereas the major portion is absorbed by the soil. Broadcasting of powdered superphosphate produces the largest contact of the fertilizer with the soil and thus promotes to a maximum degree the conversion of the readily soluble superphosphate to a sparingly soluble form. The result is that the major portion of superphosphate is used for "fertilizing the soil" and not for providing nutrition to the plants.

Stubble Mulch Studies: III. Influence of Soil Microorganisms and Crop Residues on the Germination, Growth and Direction of Room Growth of Corn Seedlings. *By* T. M. MCCALLA *and* F. L. DULEY; *Proc. Soil Sci. Soc. of Amer. Vol. 14, pp. 196-199. 1950.*

A laboratory study of some factors involved in stubble-mulch farming that reduce germination and growth of corn seedlings was made. Corn germination in soil mulched with wheat straw was less than in bare soil even though both test soils were maintained in an excessively wet condition.

It was found that a mineral agar medium containing a source of organic nitrogen stimulated the growth of soil microorganisms which caused the roots of corn seedlings to grow upward. Kernels of corn soaked in a plant material-water mixture for 24 to 48 hours, and then placed on an agar medium usually gave seedlings with a small percent of their roots growing upward. When organic nitrogen compounds were added to a mineral nutrient agar they stimulated the production of substances by microorganisms which caused a high percentage of the seedling roots to turn upward. The growth of these seedlings was greatly reduced as compared to the seedlings in the control. Germination was reduced with water extracts of sweetclover and wheat straw plus 0.5 per cent ammonium nitrate. The compounds containing organic nitrogen reduced germination only slightly even though in most cases the sprouted kernels made very little growth.

The Use of Woody Materials on Agricultural Land: A Review. *By* ROY B. DAWSON; *USDA, SCS-TP-99. August 1950.*

This is a review of recent work on the effect of woody materials on soils and plant growth. The use of other crop residues and their relationship to soil toxicity has also been reviewed to a limited extent. Although the literature coverage is by no means complete, it may serve to point out some of the real problems involved and to suggest possible methods of solution.

This review indicates that harmful effects on the growth of cultivated plants of sawdust and other woody materials when added to the soil are caused chiefly by a decrease in available nitrogen. Where woody materials are used along with adequate fertilization, or after proper composting or weathering, there is apparently little or no evidence to support the currently popular belief that toxic materials are released.

Machinery Requirements for Stubble-Mulch Tillage. *By* G. E. RYERSON; *Agr. Eng., Vol. 31, No. 10, pp. 506-508 and 510. October 1950.*

In order to control erosion and maintain productivity there are other things that must be done simultaneously to the soil in addition to the job of merely preparing seedbeds, planting and harvesting crops. It is necessary that a protective cover, either in the form of growing vegetation or as a mulch, be maintained on the surface for as much as possible of that period of the year when erosion losses are most likely to occur. The author explains what is necessary to accomplish this objective.

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Soil Conservation Surveys

(*Continued from page* 145)

different types for football and baseball, boots for riding, heavy shoes for work, oxfords for dress, hip boots for wading, and slippers for ease (if we are fortunate enough to have any). A man playing tennis in hip boots is a clown; a man wearing football shoes to a dance is suspect of a variety of aberrations—none good. Footwear should be approproiate to the needs of the occasion.

And so it is with designing soil conservation surveys to do specific, special jobs. Designing a survey is a real challenge to the soil scientist. It calls upon the sum of all that he is at that moment—in experience, training, judgment, intelligence, and resourcefulness.

He should consult with the person requesting the survey to find his requirements and the proposed use of the survey. Then he should design the survey to fit the need in terms of scale, base map, ranges of various physical factors to be shown, symbols, amount of categoric detail, and the like.

The challenge is great, but so is the reward. The reward is an ever greater service to the public through soil conservation surveys.

Corn Belt Agriculture

(*Continued from page* 124)

(4) Duley, F. L., Russell, J. C. "Stubble Mulch Farming to Hold Soil and Water," Farmers' Bulletin No. 1997, U. S. Department of Agriculture.

(5) Dreibelbis, F. D., Nair, M. S., "Is Plowing or Disking Better on Cornbelt Soils?" What's New in Crops and Soils, April-May 1951.

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(7) Haynes, J. L., "Ground Rainfall Under Vegetative Canopy of Crops," Journal Amer. Soc. Agron. 32:176-184, 1940.

(8) Kurtz, L. T., Appleman, M. D., and Bray, R. H., "Preliminary Trails With Intercropping of Corn and Clover," Soil Science Soc. Amer. Proceedings 1946, Vol. II 349-355.

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(10) Wilson, H. A., Browning, G. M., and Peterson, J. B., "Cover Crops Help Save Soil," Iowa Farm Science, May 1947.

A nation deprived of liberty may win it, a nation divided may reunite; but a nation whose national resources are destroyed must inevitably pay the penalty of poverty, degradation and decay.

—GIFFORD PINCHOT.

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FIELD NOTES AND COMMENTS

Trained Agriculturists Are Needed to Represent This Country Abroad

Six hundred agricultural specialists from all parts of the United States are needed to represent this country abroad in technical cooperation programs, including the Point Four program, under present plans of expansion.

The Office of Personnel, Department of Agriculture, is developing a national roster of professional agriculturists to be used by the Department, and other Federal and public international organizations, in recruiting personnel for foreign assignments. Qualified specialists are urged to apply for these positions, and their employers are urged to cooperate in making their services available so that this peace-building work may proceed rapidly. Those who receive appointments will be contributing to an important phase of national foreign policy, the Department advised.

As technical cooperation programs expand, trained agriculturists will be called for in increasing numbers to serve in professional capacities in foreign posts, the Department said. Under present plans both the number of countries participating and the number of U. S. agriculturists serving in each will be increased.

The program requires employees with professional academic training and several years of responsible professional experience in the field of agriculture. Applicants must be skilled in their professions, have leadership ability and maturity of judgment, and generally be capable of filling the role of agricultural statesmen as they represent the United States abroad.

Areas into which agricultural specialists will be sent include Europe, Latin America, Africa, the Near East, and the Far East. Agricultural Educational institutions, many of whom have already supplied research and extension leaders now abroad, will be urged to send additional members of their faculties and staffs on these assignments.

Research and extension are the principal categories of work in agricultural aspects of technical cooperation. The greatest need is for individuals trained in research or extension phases of soils, land use, forestry, crops, animal husbandry, pest and disease control, agricultural engineering, economics and marketing, and social sciences.

Appointments are exempt from Civil Service examination. Rates for the seven classes of specialist positions range from $5,370 to $10,330 a year. Candidates preferably should be from 30 to 60 years old. Applicants over 60 may be considered for some assignments. Travel expenses to foreign posts for the specialist and dependents will be paid by the Government. Employees also may receive quarters and living allowances, as well as the special Foreign Service health and leave benefits, and in some cases post differentials of from 10 to 25 percent.

Persons interested in the assignments, who are qualified as a result of professional academic training and several years of responsible professional experience in the field of agriculture, are asked to write to the U. S. Department of Agriculture, Office of Personnel, Washington 25, D. C.

Land Leveling and Irrigation Done in China With Crude Tools

Technicians consider working with irrigated land, laying out irrigation systems and land leveling as precision jobs. And because of this requirement for precision, they are supplied with the finest engineering instruments, and contractors with excellent equipment are available for earth-moving operations.

Not so everywhere, however. Nor is land leveling—or smoothing—something new. It is as old as the hills, figuratively. In many places on this old earth, water distribution systems are still in use after many generations of operation. And even today, the irrigation and land leveling are carried on successfully, but laboriously, "by eye" and with crude methods of the ancients.

How crude it is, was forcibly impressed on me during my service with the Army near Kumming, China, during World War II. There I saw rice farming—the system of paddies, the "water-leveling" of the land, the planting and harvesting of the rice crop.

Rice is a hot weather crop, which must be grown under flooded conditions. Therefore, a field to be used for rice growing must be leveled carefully. The practice of water leveling used in this part of China is ancient, originated

Photos made available through the courtesy of Captain Albert Eickhoff, Army Information Service, Carlisle Barracks, Pennsylvania, and Maynard Wankier, Soil Scientist, Chinook, Montana.

Figure 1. A farmer and his wife using the type of pump described in the text of the article. The water is being pumped from a sump into a diversion ditch. In this case, two lifts are needed to raise the water the required distance.

Figure 2. Chinese women planting rice in a paddy that has just been leveled. Note that the level of the water in all the paddies is about the same. This picture also gives a close-up view of a paddy that has not been water leveled. It is the one behind the paddy being planted.

by some long past generation.

Water buffalo still provide most of the power for leveling. The water buffalo is a rugged animal with a fierce disposition toward strangers, especially during the breeding or mating season. He has a thick, black hide that equips him admirably for working in the knee-deep mud of a flooded rice paddy. He is extremely valuable to the Chinese farmer, and for this reason is stabled inside the village compound—usually in his owner's house.

Once demesticated, the water buffalo is managed by being kept continually on a leash. The leash consists of a leather throng tied through the beast's nose, and it is used to guide him when he is draft. For water leveling a rice paddy, the water buffalo is usually hitched to a crude wooden spike-tooth drag.

Rice paddies are extremely irregular in size and shape. This is due principally to the fact that the Chinese farmer has never been equipped to carry on earth-moving operations on a large scale. Instead, he has to work piece-meal on small tracts, patiently doing a little bit at a time with crude hand tools such as shovels, hoes, and bamboo wicker baskets. The rice paddies, consequently, follow the general lay of the land. As his family became larger, the farmer was forced to figure out how he could lay out another rice paddy adjacent to those already in use.

Once the general form of the paddy was figured out, the original levels were arrived at by eye and by the water level of adjacent paddies. Then a small dike, eight to twelve inches high and wide enough to form a narrow footpath, was built around the outside border.

Spring plowing followed by water leveling are necessary each year. Plowing may be done by a team of water buffalo pulling a wooden plow that is often little more than a forked tree trunk hewn by hand into a plow. Frequently, the paddies are plowed by hand. After spring plowing is finished, water is diverted into the rice paddy from nearby streams or it may be pumped into a diversion ditch from a sump or well.

Man and woman power are most commonly used for pumping. One of the accompying pictures shows a pump that is made entirely from bamboo and wood. It consists of a long trough through which square wooden paddles pass. These wooden paddles are connected to an endless chain and the chain is geared to a centric wheel. Two long bamboo poles are attached to the wheel. By pushing and pulling on the poles, the operator draws the paddles through the trough and forces the water along in the trough.

When the paddy has been about half filled with water, high spots usually still show above the water. These must be eliminated by dragging, for which the water buffalo is used. It takes much persuasion to induce the water buffalo to pull a drag back and forth across the paddy. But it is continued until the high spots are no longer visible. When this point is reached, the paddy is considered to be ready for planting.

Actually, the accomplishments of these farmers near Kumming, China, are remarkable. They have developed their systems of rice paddies, water supplies and water leveling operations with nothing but the crudest tools and methods. They have had no engineering instruments or modern equipment—only patience and native ingenuity.

—DEWITT ABBOTT, *Lincoln, Nebraska*

Conservation Program Well Under Way in Colombia, South America

For a long time deforestation, lack of protection against hard rains, and the unsuitable way of slope cultivation of the Andes have created a very serious problem for Colombia, permitting erosion (washing and dragging down the soil by rain water) to impoverish the lands of the mountains (cordilleras) and to carry away the richest soil towards the rivers and the sea.

In order to arrest such a serious danger, the National Federation of Coffee Growers three years ago established *"la Campana de Defensa y Restauracion de Suelos"* (a campaign for the defense and restoration of soil) with an annual approximate budget of a million pesos and a personnel of 100 professionals and technicians. This institution works arduously in the 12 coffee growing departments (states) of Colombia to teach farmers how to cultivate their lands, how to protect soil from erosion,

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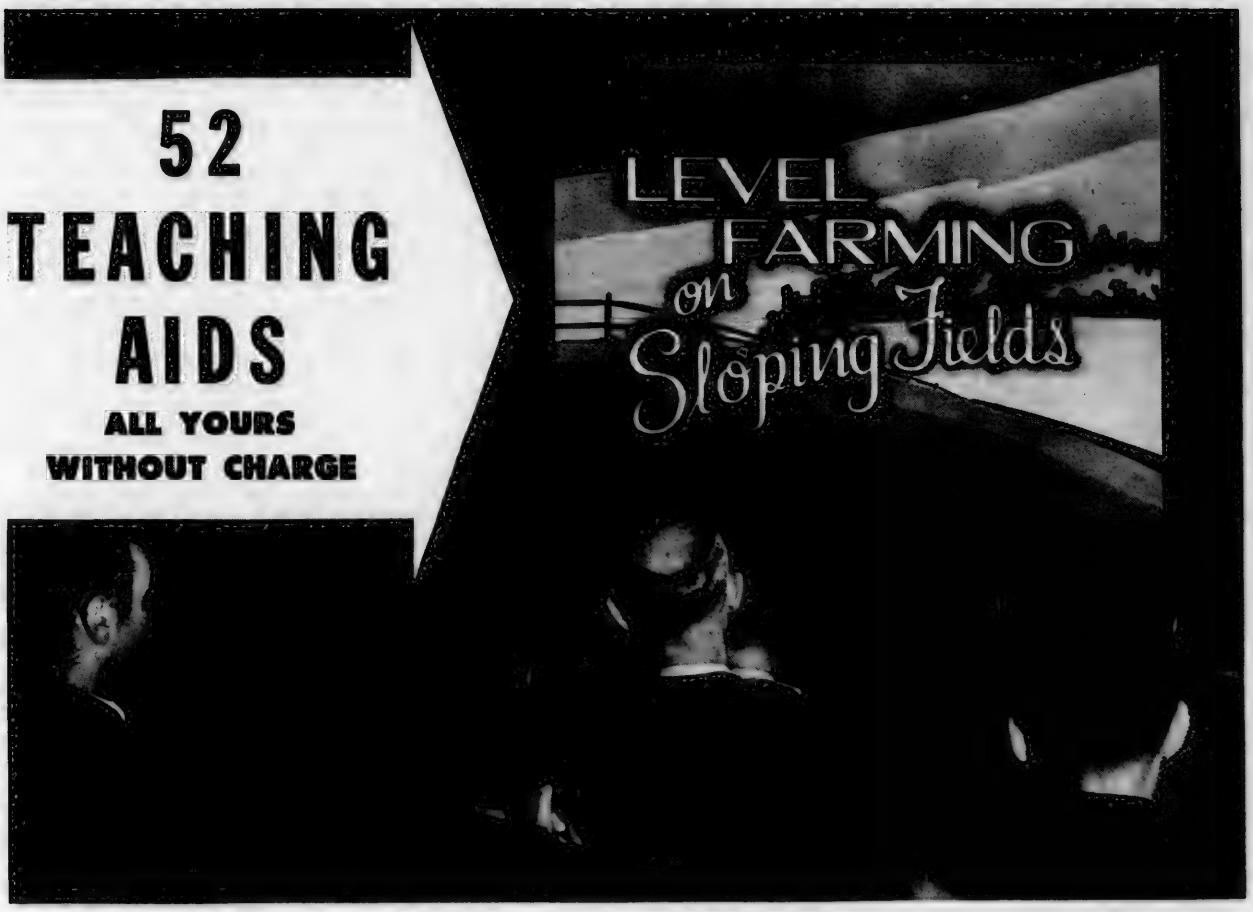

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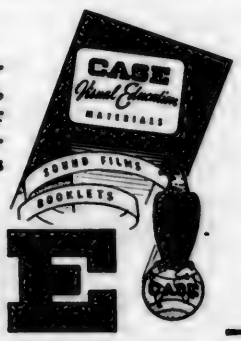

CASE

Films are loaned and printed matter provided without charge to agricultural leaders and appropriate groups—county agents, extension workers, vocational agriculture teachers, civic and farm clubs. Schedule movies through your nearest Case dealer or branch, or write direct to Educational Division, J. I. Case Co., Racine, Wis.

and what the practical procedures are to obtain a better living for themselves and their families from their farms.

The Campaign for the Soil Conservation of the Federation of Coffee Growers is integrated in two branches, namely: A) the Division of Experimentation, and B) the Field Division.

The Division of Experimentation working in the Experiment Station of the federation at Chinchina (Caldas), investigates the most important problems of erosion in the coffee-growing zone. The experimental runoff plots with their investigation of the loss of soil and water occurring under different conditions of sloping, vegetative covering, etc., the pastures that protect the soil; the methods to avoid the removal of important nutrients, the study of the leguminous plants that enrich the lands, etc., are only some of the problems under experimentation in this important section of the campaign.

The Field Division has at present 16 sectional offices, headed each by an agricultural engineer, a specialist in soil conservation. Their work in the way of demonstration, study and teaching in the coffee plantations is realized by the help of various so-called "Commission Chiefs" (well trained farmers) who direct the work teams.

The objective of the campaign is a double one: To teach the farmer to protect his land against soil erosion, and to instruct him in simple, but effective, systems which will enable him to obtain more coffee, better crops, and a greater quantity of pasture on the land under his cultivation.

On every farm, in the coffee-growing zone, the agricultural engineers of the campaign make an economic study of the properties, determine the characteristics of soils, evaluate the slopes and, together with the farmer himself, work out a five-year plan that the federation helps the coffee-growers fulfill.

Until now, the campaign is the most efficient and technical means of agricultural promotion that has been produced in Colombia. By means of it, the farmers not only receive a detailed study of the soils of their farm and the advice of the agricultural engineer, but they see in the way of demonstration the result of the systems that the federation of coffee-growers want them to promote to protect and improve the soil.

F. SAUREZ DE CASTRO, *Colombia, South America*

Trailing Raspberry Has Variety Of Uses in Conservation Program

Trailing raspberry, an introduced plant, shows promise for erosion control on difficult sites, and possibilities for producing food for wildlife and fruit for farm families. Numerous tests have been made with it in the Northern Great Plains.

Photo by Soil Conservation Service

Figure 1. This is the bank of the natural drainages behind the farm pond on the Adolph Habrich farm near Pawnee City, Nebraska. The soil is poor—known locally as *"buckshot gumbo."* This slope was planted in 1942 with trailing raspberry plants. The plants thrived, increased in number, and now control erosion on this slope. In addition, they supply quantities of fruit that is relished by the Habrichs.

Trailing raspberry was introduced into the United States from Japan in 1929 by P. H. Dorsett and J. W. Morse of the Division of Plant Exploration and Introduction, Bureau of Plant Industry. Soon after introduction in testing stations in Maryland and North Carolina, plants were distributed to nurseries in many localities for observation and testing.

Correctly identified, it is known as Crimson-flowered trailing raspberry, *Rubus parvifolius.* It is true trailing red raspberry with long, moderately thorny canes. The fruit is attractive in color, size and flavor. There is little or no bloom on the fruit, which resembles that of dewberry (trailing blackberry) in the darker fruited strains.

Recipients of the early allocations hoped they had been freed of the worry and care of producing an acceptable raspberry for general use outside of the recognized commercial berry growing districts. They had several qualities on which to base these hopes. The plant is hardy shade-and-sun-tolerant, vigorous, free from disease, and will grow in a wide range of soils having variable rainfall and temperature conditions. It roots freely from the tips of canes. Under undisturbed field conditions, it spreads rapidly and forms a dense cover for protection of soil and wildlife.

Widespread planting tests in this country have led to abandonment in some areas of its use as a conservation plant, but strong success is indicated east of the 24-inch rainfall line in Kansas and Nebraska. There seems to be no indication that it can compete with grasses and kudzu, but it certainly has a use in special situations.

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The Golden Rule of Harvesting

Over 3,700 years ago (18 centuries before Christ), the above words were engraved in Babylonia on a clay tablet — the earliest known agricultural bulletin.

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The ALL-CROP successfully harvests more than 100 different crops from feathery grass seeds to large beans. Full-width, rubber-shielded cylinder handles seed gently. Instant cylinder speed control, oversize separating capacity and saw-tooth wind valves assure a clean harvest.

Every home-owned ALL-CROP Harvester is an asset to grassland farming. Good seed can be harvested from pastures and meadows. It assures an adequate supply of seed for re-seeding and expanding grass and legume acreages on the farm, as well as providing extra income from seed sales.

It's good advice to "cut it at the right moment" with a home-owned ALL-CROP Harvester.

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3-IN-1 FORAGE HARVESTER

(1. Grass sickle bar attachment, 2. Windrow pickup for sickle attachment, 3. Row-crop attachment.) The Allis-Chalmers Forage Harvester provides your choice of harvesting methods. Advanced, labor-saving design includes built-in knife sharpener.

ROTO-BALER

Rolls hay into bales that seal in the leaves . . . seal out the weather. It's baling at its best — captures the fragrant leafiness, color and protein, and preserves more goodness of the growing plant.

Apparently trailing raspberry is cosmopolitan as to soils and site locations. It seems as thrifty on poor Dakota sandstone soils found in Lancaster and Saunders counties, Nebraska, as in deep, loess soils in Brown County, Kansas; it has grown vigorously in deep sandy soils at the Soil Conservation Service nursery at Manhattan, Kansas, and is doing well on poor soil on a difficult site in Pawnee county, Nebraska.

Besides its value for erosion control and wildlife feed and cover, trailing raspberry is valuable to farm families because of its fruit. Families on farms where it has been planted have enjoyed the fruit fresh and in pasteries, jams and jellies. Tests made by the home economics department of Kansas State College brought a favorable verdict.

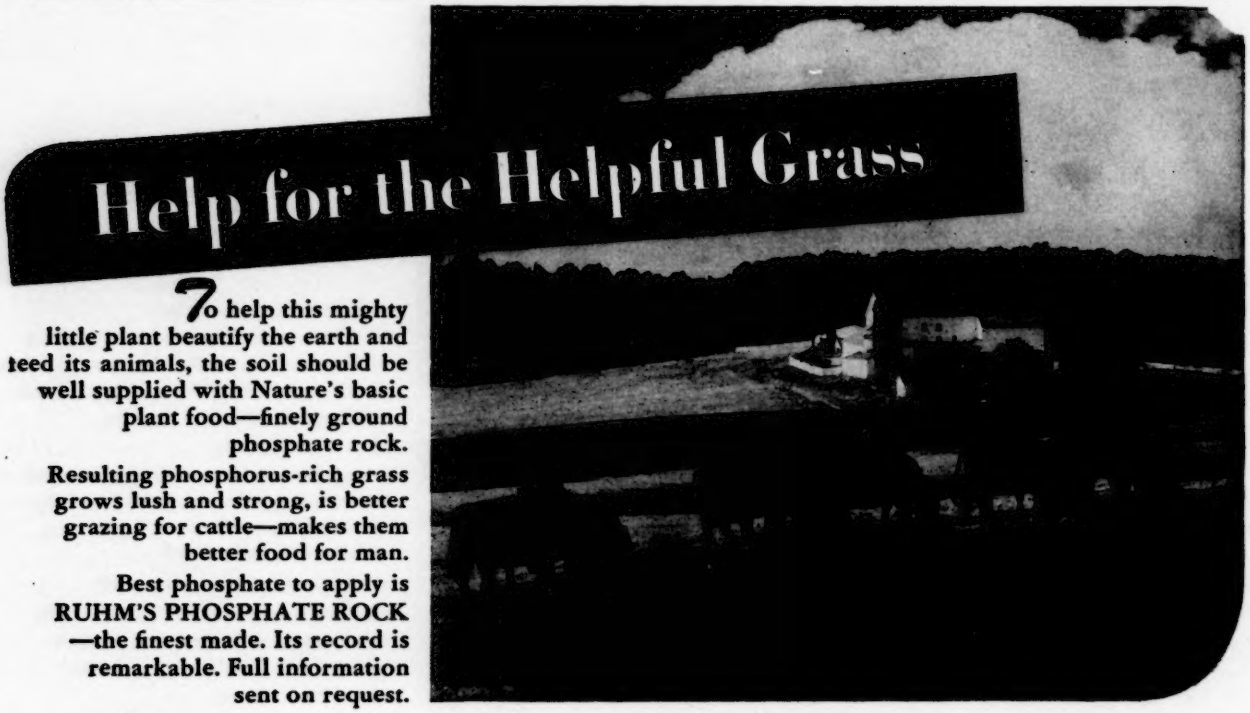
Some observers have reported poor fruit production from trailing raspberry plants. This may be due to a combination of factors, such as heredity, late freezes, poor pollination conditions, dry weather or low plant vigor.

A few general statements, which apply particularly to planting trailing raspberry in the eastern half of Kansas and Nebraska, follow:

1. The plant is not too particular about soil fertility and will grow on a wide range of soils east of the 24-inch rainfall line.
2. Initial plantings require some form of cultivation for at least two years in order to compete with other vegetation.
3. The plant is moderately shade tolerent and will grow beneath and along the edges of tree and shrub rows.
4. Established plantings provide excellent ground cover and are especially adapted for use in providing nesting and feeding places for birds and small game.
5. The fruit is of acceptable quality, suitable for pies, jelly, jam, tarts, and fresh desserts.
6. The plant is quite resistant to bramble diseases and is not greatly damaged by insects and rodents.
7. New plants may be obtained from seed or from cane tips covered with soil in midsummer.

Old plantings, if renovated, may regain vigor and fruit production. Renovation is accomplished by cutting out old canes, thinning plants, applying fertilizer if needed, and frequent tillage after plowing between rows.

—FRED P. ESBAUGH, *Manhattan, Kansas*



To help this mighty little plant beautify the earth and feed its animals, the soil should be well supplied with Nature's basic plant food—finely ground phosphate rock.

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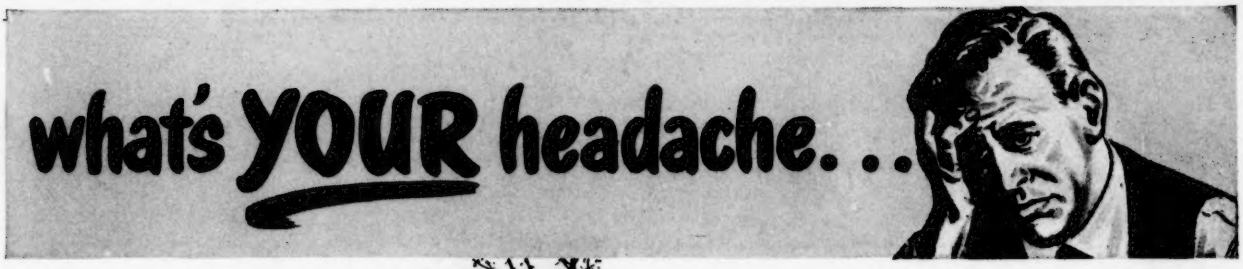
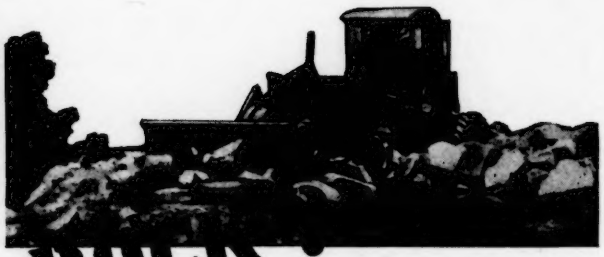
what's YOUR headache...



BRUSH

An area to be cleared before a diversion ditch can be cut . . . bulldozer and grader blade provide the one-two punch that gets the job done easily and quickly.



ROCK

On an A-W Power Grader the bulldozer becomes a rough, tough tool . . . extra sturdy to match the extra power of ALL-WHEEL DRIVE, and fully up to this job of handling heavy rock.

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Live, climbing power at both ends of the machine keeps it bulldozing steadily through sand where an ordinary grader would find it difficult to travel, let alone work.

TREES ?

First, the grader blade with its deep-plowing ability is socked into the ground to undercut the tree roots; then the bulldozer, backed by the superpower of ALL-WHEEL DRIVE, finishes the job.

there's a **JOB** to be done

Yes . . . Lots of things to Push Around . . .

and one *very good way* to do it is with an A-W Power Grader with its exclusive All-Wheel Drive and All-Wheel Steer for maximum traction and maneuverability. The Bulldozer is an essential for many jobs . . . a time and money-saver for dozens of others.

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